

**IMMERSIVE EDUCATION:  
VIRTUAL REALITY IN CLINICAL AUDIOLOGY**

*A pilot study of the effectiveness of a new patient simulator program on audiology  
students' performance on case history tasks*

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## **Abstract**

*Purpose:* Hearing loss is a common problem worldwide, and there is an ever-increasing need for more audiologists to be trained. Unfortunately, audiology students cannot always get the clinical experience they need during training. Virtual reality involving computer-based simulation of real-life training experiences is one way of compensating for this. While there are several virtual audiometers available for student use, few of these include the vital case history component. This study sought to develop an interactive virtual patient that includes this component, and to objectively measure the effect of training with this software on student performance.

*Method:* Development of the Patient Simulator Program (PSP) took place in two phases – Phase One involved development of audiometric information and a brief case history summary for 25 patient cases, and Phase Two involved development of comprehensive case histories for these and identification of triggering phrases and keywords for eliciting each piece of information from the virtual patient. Twelve first year audiology students were recruited from the University of Canterbury and divided into matched groups based on their pre-test scores. An alternating treatment design across groups was used to evaluate participants on their verbal and written accuracy, experience, confidence, and efficiency scores on case history tasks.

*Results:* A significant difference was found in verbal accuracy scores between groups at the mid-way assessment point (following simulator training), but not for written accuracy. Differences between groups were not significant at all assessment points for efficiency and experience measures. Confidence gains were greater for the second group to train with the simulator than the first, while performance gains were greater for the first group.

*Conclusion:* These findings support the evidence that simulation training can enhance student's skills, and provide the first objective evidence for the benefits of training for case history tasks with an interactive virtual patient. While the effect size was small, these findings are a promising springboard for future research into this area. While the PSP is not adequate to replace real clinical encounters, it has potential as an adjunct to the current training program.

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## List of Abbreviations Used

PSP	Patient Simulator Program
NZAS	New Zealand Audiological Society
VR	Virtual Reality
ISP	Interactive Simulation of Patient Cases
VIC	Virtual Interactive Character
VSP	Virtual Standardised Patient
SLE	Simulated Learning Environments
HIT Lab NZ	Human Interface Technology Laboratory New Zealand
ENT	Ear, Nose and Throat
SPSS	The Statistical Package for the Social Sciences
DNA	Did Not Attend
WHOQOL-100	World Health Organisation Quality of Life Instrument-100
PD	Psychological Domain
ED	Environmental Domain

# **1 Literature Review**

## **1.1 The Profession of Audiology**

### **1.1.1 Introduction**

Hearing loss is a common medical disorder that is estimated to affect around 1 in 10 people worldwide (New Zealand Audiological Society Inc, 2010). This translates to around 400,000 affected New Zealanders – each of whom are likely to require audiological assessment or intervention at some point. For some, hearing loss occurs at birth or very early in life, which can adversely affect language development, oral communication, educational progress and cognitive processes. However, early identification and audiological intervention can minimise some of these negative effects of early hearing loss (Sininger, Grimes, & Christensen, 2010). Other causes of hearing loss include trauma, noise exposure and various medical conditions.

Additionally, hearing loss is associated with the ageing process. The number of people aged 65 and over in the New Zealand workforce is projected to treble from the year 2001 to the year 2026 (Statistics New Zealand, 2006). This trend is reflected worldwide, with projected growth in the proportion of the population aged 65 and over in Europe, Northern America, Oceania, Asia, Latin America and the Caribbean, and Africa (United Nations, 2006).

Studies estimate the prevalence of hearing loss among people over 75 years old at 40%, whereas other studies have reported a prevalence of 90% in populations over 80 years old (Huang, 2007). Within the next twenty years over one quarter of New Zealand's population is likely to consist of people aged 65 years or older

(Statistics New Zealand, 2006), which is significant growth from only twelve percent in 2005. This change will account for 87% of the total population growth in New Zealand between 2005 and 2051 as a result of lower mortality and lower fertility rates. With this ever-increasing prevalence of hearing loss, there is a growing need for more audiologists to be trained in order to meet the needs of this population.

### **1.1.2 Audiology Education**

The American Speech-Language-Hearing Association (2004) defines audiologists as professionals engaged in autonomous practice to promote healthy hearing, communication competency, and quality of life for persons of all ages through the prevention, identification, assessment, and rehabilitation of hearing, auditory function, balance, and other related systems. Audiologists work with patients of all ages and will encounter a wide range of impairments and disorders throughout their clinical careers and, as such, require comprehensive and detailed clinical and theoretical training.

There are many university programmes worldwide offering Masters or Doctorate degrees in Audiology. New Zealand has two such programmes, one at the University of Canterbury and the other at Auckland University. In order to obtain full membership of the New Zealand Audiological Society (NZAS), applicants are required to have completed at least a Masters Degree in Audiology or a postgraduate qualification equivalent to a Masters Degree in Audiology from an accredited or endorsed New Zealand University (New Zealand Audiological Society Inc., 2010).

The NZAS specifies that graduates completing a Masters in Audiology will have knowledge and understanding of (1) Hearing Sciences, including acoustics and the basis of audiological instrumentation, the anatomy and physiology of the auditory

system, the anatomy and physiology of the balance system, and the psychology of hearing and hearing loss; (2) Diagnostic Audiology, including the theoretical bases of audiometric procedures, the procedures for behavioural and objective evaluation of the auditory system in children and adults, and evaluation of the vestibular system; (3) Otolaryngology and Diseases of the Ear, including the causes, mechanisms, diagnosis, management of hearing disorders and ear disease, causes and treatments of diseases of the head and neck, and the prevention of hearing loss such as from noise exposure; (4) Pediatric and Adult Aural Rehabilitation, including clinical management of hearing disorders through the use of hearing aids, cochlear implants, assistive devices and counselling, and the management of tinnitus; and (5) Psychosocial, cultural and ethical issues relating to hearing loss (New Zealand Audiological Society Inc., 2011, pp. 1-2).

Additionally, graduates are expected to, among other things, have the ability to take an accurate, organised and problem-focussed patient history, integrate and interpret the history and results of the diagnostic assessment to arrive at an appropriate conclusion, select an appropriate intervention, management and rehabilitation plan in concert with the patient, and communicate clearly, considerately and sensitively with patients, their families, caregivers, other health professionals and the general public (New Zealand Audiological Society Inc., 2011, p. 2).

Audiology training programmes in New Zealand are required to provide a learning environment that allows clinical training relating to a variety of settings, client populations, and age groups (New Zealand Audiological Society Inc, 2011, pp. 1-2). This includes a minimum of 250 supervised 'Direct Contact Hours', made up of no more than 50 Direct Contact Hours of supervised clinical observation and a minimum of 200 Direct Contact Hours of supervised clinical practice. The NZAS

defines Direct Contact Hours as time spent in actual assessment or rehabilitation of clients suspected of or having a hearing or balance disorder. The total 250 hours of supervised Direct Contact Hours should include a minimum of 40 hours of pediatric hearing evaluation, 40 hours of adult hearing evaluation, and 80 hours of amplification and assistive devices including a minimum of 10 hours pediatric and 10 hours adult habilitation.

In order to achieve these goals the NZAS has specified standards for the educational programmes offering a Masters Degree in Audiology. It is expected that there are defined learning outcome for the programme and that the departments involved can demonstrate how these outcomes are achieved, and that the students will have sufficient patient contact, with appropriate diversity, to acquire clinical knowledge, skills and professional attitudes that enable them to assume appropriate clinical responsibility upon graduation. Additionally the universities are expected to employ teaching and learning methods appropriate for the content and outcomes of the programme, and select teaching and learning methods for clinical training and practice education that reflect the contemporary scope of audiology practice. Educational resources are expected to be sufficient for staff and students to ensure that the curriculum can be delivered adequately, and it is expected that there is access to adequate clinical experience and associated resources, including sufficient patient contact and clinical training facilities.

### **1.1.3 Clinical Education**

Zary, Johnson, Boberg & Fors (2006) have said that much of the professional development of a student happens when he or she meets patients, and educators agree that good diagnostic skills can only be obtained through repeated exposure to patients

(Dickerson, Johnsen, Raij, Lok, Hernandez, & Stevens, 2005). Slosberg & Levitt (1978) postulated that specific skills such as critical observational skills (both aural and visual), sound clinical judgement and the ability to work effectively with patients are, although necessary to become a good clinician, not easily learnt through coursework or in the standard classroom setting. Lectures, textbooks and even clinical experiences often do not provide students with enough information or feedback to make them into confident clinicians (Sistrunk, 2002). Students develop clinical reasoning skills by seeing many patients, actively engaging in problem-solving, and receiving sufficient feedback (Huwendiek, Reichert, Bosse, de Leng, van der Vleuten, Haag, Hoffmann, & Tonshoff, 2009).

Bowen (2006) identified some key educational strategies for the promotion of clinical reasoning. These include asking open-ended questions, providing single sentence summaries of patient problems in abstract terms, asking for discriminating features of a set of diagnostic hypotheses, early probing for differential diagnosis, prioritising diagnoses, and encouraging students to compare and contrast diagnostic hypotheses and the relative probabilities of different diagnoses. These strategies are often employed by educators in conjunction with the supervised clinical practice component of an Audiology programme. Traditionally, Audiology students receive instruction through lectures, coursework, textbooks, online materials and observation of and participation in supervised clinical practice.

To enable students to attain ‘sufficient patient contact with appropriate diversity’ and to ensure ‘access to adequate clinical experience’, as per the NZAS specifications, many student placements take place off-site. While many university training programmes run their own clinics on campus they do not typically see the full spectrum of patients and it has been identified that many university clinics lack good

educational cases because most “normal” or more typical patient cases are handled outside the university clinics (Bergin & Fors, 2003).

The organisation of external placements can be time-consuming for course coordinators, and practice supervisors often have limited availability (Alinier, Hunt, Gordon, & Harwood, 2006). Research into Speech and Language Therapy – a field similar to Audiology in the structuring of its courses and external clinical placements – found that working Speech and Language Therapists are becoming less and less able to take students due to increased demands for cost-effectiveness and productivity in the workplace, and when they do take students they tend to have limited time available for teaching during the working day (McAllister, 2005). Growth in the number of programmes and increases in student numbers places even greater demand on external supervisors, and with a typical one-to-one ratio of supervision external placements can be hard to come by (McAllister, 2005).

Further, some patients are unwilling for students to take part in or observe their assessment or treatment, or ethical considerations make them unsuitable for students (Zary, Johnson, Boberg, & Fors, 2006; Bergin & Fors, 2003). Patient safety is also a consideration (Ziv, Small, & Wolpe, 2000; Bradley, 2006; Slosberg & Levitt, 1978), and the organisation and implementation of sourcing adequate experiences for students, student feedback and correspondence, problem-solving with students, and student assessment are further barriers to attaining sufficient patient contact (Theodoros, Davidson, Hill, & MacBean, 2010).

On top of this, Audiology training programmes are becoming shorter in duration (Bradley, 2006). Although students perceive these short timeframes as necessary they report feeling overwhelmed by the amount of information to be learned and applied in the clinical setting, and that they have insufficient time to



emerge as confident clinicians (Sistrunk, 2002). Students may also have shortened clinical periods as the introduction of new subject areas pressures the curriculum (Bergin & Fors, 2003). Additionally, there can often be discrepancies between what is taught in the classroom and what is taught clinically – clinical shortcuts are often used that do not match up with what the students learnt in lectures (as this cannot always be feasibly applied in a busy clinic), or students see scenarios clinically that they have not yet discussed in class and vice versa (Sistrunk, 2002).

Bowen (2006) reports that medical students' knowledge is often cognitively organised according to how it was taught in the classroom, so in order to retrieve this information they will need to be prompted by questions related to how the information was organised in the curriculum or by other contextual cues. This means that when seeing patients for the first time retrieval of this knowledge can be a slow and awkward process. Only once connections have been made between the knowledge and clinical encounters do students become more proficient and confident in their clinical reasoning and decision-making.

Unfortunately, it is not always feasible for students to get the amount of practice that they require. Slosberg & Levitt (1978) reported that there are at least two potential problems with sending students on external placements. Firstly, this method of training can be financially costly to both the university and the clinics themselves. As such, there is the temptation to reduce expenses by maximising the student's workload – resulting in a likely reduction in quality of patient care. Secondly, the quality of the training that students receive can vary greatly from setting to setting, which can leave some students with significant gaps in their clinical experience. Changes to the current educational model are needed to supplement students' learning and to attempt to counteract for these potential gaps in clinical experience.

## **1.2 Virtual Reality in Education**

Virtual Reality (VR) software involving computer-based simulation of real-life training experiences has been used since the 1960s (Bradley, 2006; Slosberg & Levitt, 1978). True VR refers to a totally synthetic environment where cues for all senses are computer generated (Ziv, Small, & Wolpe, 2000; Sitzmann, 2011), but here the term will not be used in its complete sense, but rather to discuss predominantly visual and auditory, and occasionally kinaesthetic virtual reality.

While VR has a range of functional uses, it is widely used in the gaming industry. Simulation games immerse the user in a decision-making exercise in an artificial environment in order to learn the consequences of their decisions (Sitzmann, 2011). Simulation games are intrinsically motivating (Malone, 1981), and when users are intrinsically motivated they put more effort into learning the material, enjoy the learning experience more, and are more likely to apply what they have learnt outside of the simulation environment.

There are three main theoretical frameworks for the use of simulation games: the Cognitive-Oriented Learning model, the Input-Process-Outcome model, and the Theory of Interactive Cognitive Complexity. The Cognitive-Oriented Learning model uses Malone's (1981) theory that simulation games are intrinsically motivating, while the Input-Process-Outcome model sees the input of instructional content and game characteristics and the process of the repeated game cycle itself to result in the outcome of the learning and transference of skills learnt from game play to real-world scenarios (Garris, Ahlers, & Driskell, 2002). Finally, the Theory of Interactive Cognitive Complexity proposes that learning is the result of an interaction between internal and external variables that affect the cognitive systems of the user (Tennyson

& Jorczak, 2008). While each theory has its merits, overall they indicate that an ideal simulation game will combine entertainment with active learning materials to immerse the user in the course material. If the simulation is entertaining then users are more likely to repeatedly engage in the learning experience and be more motivated. Active learning principles give the user the responsibility for making important learning decisions, and rely on inductive learning in which users must infer the rules for effective performance by exploring the task.

Sitzmann (2011) conducted a meta-analysis of 65 independent samples from more than 6,000 trainees from 1976-2009 to determine whether virtual games could be effective for improving work-related knowledge and skills. Comparison groups differed from no-training controls to alternative methods of training. Sitzmann's review revealed three categories of outcomes: affective outcomes, cognitive outcomes, and skill-based outcomes. Affective outcomes include self-efficacy, which is confidence that one has learned the information taught in training and can perform training-related tasks (Bandura, 1997), motivation and trainee reactions. Simulation games resulted in higher self-efficacy post-training than a comparison group when learning how to treat children with autism (Randell, Hall, Bizo, & Remington, 2007), and Sitzmann's (2011) meta-analysis revealed an increase in self-efficacy of 20% with simulation training. Cognitive outcomes, on the other hand, include improvements in declarative knowledge: memory of facts and principles taught in training and the relationship among knowledge elements, and retention: memory of factual information taught in training several weeks or months after leaving the training environment. Finally, skill-based outcomes are comprised of procedural knowledge and transfer, which refers to the successful application of the skills gained in training to the job. Sitzmann (2011) identified that further research is needed to

identify the affective, behavioural and cognitive training outcomes from specific characteristics of simulation games.

A further meta-analysis of the instructional effectiveness of simulation games for teaching adults and children revealed that learning gains were greater after using simulation games compared with traditional teaching methods alone across 8,549 participants (Vogel, Vogel, Cannon-Bowers, Bowers, Muse, & Wright, 2006). Outcome measures used to define the success of simulation throughout the literature include clinical skills, training time, errors, and personal improvements – such as confidence and communication (The Physiotherapy Consortium, 2010).

Full-scale patient simulators, which are body-sized mannequins with realistic anatomical and interactive physiological features (Alinier, Hunt, Gordon, & Harwood, 2006), started in the 1960s in America (Abrahamson & Wallace, 1980). These are also known as High-Fidelity Simulation Platforms (Alinier, Hunt, Gordon, & Harwood, 2006). Patient simulators attempt to compensate for some of the weaknesses of the traditional clinical education models described earlier. *Sim One* was the first patient simulator, and was used to help first-year anaesthesia residents learn to administer intravenous medications and perform endotracheal intubation. It was found that residents who used the simulator became proficient in less time and with fewer trials than residents who trained only in the operating room with real patients (Abrahamson & Wallace, 1980). Further mannequin simulators were developed during the 1980s focussing mostly on anaesthesiology medical students (Good, 2003), and at this time computer-based clinical case simulations begun developing, due largely to the advent of the personal computer (Ziv, Small, & Wolpe, 2000).

More recently, *SimMan*, a full-body mannequin, was used in a workshop for medical students to train in emergency care. The students found it a valuable learning experience that helped to increase their competency (Weller, 2004). However, the usefulness of VR simulation as a training tool extends well beyond the medical field – aviation uses high-fidelity simulation; the space programme uses simulation for training and testing, and the nuclear power industry uses simulation to practise (Bradley, 2006). There has even been investigation into the perceived motivation and emotion, skills, cognitive styles, benefits and learning outcomes of virtual reality in education for engineering students using a virtual lathe (Antonietti, Rasi, Imperio, & Sacco, 2000). All students rated the experience positively, and no statistically significant differences were found between responses from males or females. Previous experience with VR did not affect participant responses in any of the areas except for decreasing the ‘perceived attractiveness’ of the program and highlighting the need for reflective and abstract thinking during VR use.

A ‘virtual patient’ is defined as an interactive collection of attributes and symptoms which can be accessed through a controlled clinical activity, and where recommended results can be pre-determined by an instructor (Stanford University School of Medicine, 2010). Virtual patient programs may be web-based, or designed for use on a personal computer. Huwendiek et al., (2009) investigated what 104 fifth year medical students perceive as ideal features of virtual patients by presenting user interfaces that differed in graphic support, long- versus short-menu questions and the freedom of navigation around the program. They discovered that students preferred virtual cases that they were unlikely to encounter during clinical training, at an appropriate level of difficulty and that were highly interactive – free-text input was preferred to simply choosing options from a list. Additionally, the students preferred

the programs that provided specific feedback on the decisions made, contained questions and explanations tailored to the clinical reasoning process, and those that helped the students to focus on the relevant learning points by keeping the text minimal. The use of pictures, video and audio was thought to increase the authenticity of the program, and providing an authentic web-based interface helped the students to feel as though they were the doctor in charge.

Issenberg, McGaghic, Petrusa, Lee Gordone & Scalese (2005) made similar recommendations for high-fidelity simulation. They recommend that the simulator should provide feedback, encompass a range of difficulty levels, involve multiple learning strategies, be used within a controlled environment, provide defined outcomes, capture clinical variation and provide for individualised learning. A successful VR interface design should synchronise audio and visual information, eliminate multi-tasking, provide authentic contexts, decrease the predetermined navigational control as expertise develops, eliminate redundant information and maintain a stable learning environment (Grunwald & Corsbie-Massay, 2006). To avoid usability problems it is recommended that obstacles are removed to allow the user to interact with the content as directly as possible, shortcuts are provided to allow the user to skip things they have seen before, related controls are grouped closely together, and appropriate and immediate feedback is given to let the user know that their action has been registered (Kristof & Satran, 1995).

Outcomes for virtual patients have been promising. Early studies such as that by Strang & Myers (1987), who developed a virtual patient for Speech and Language Therapy students to evaluate and train in pediatric fluency, found that clinicians and students rated virtual patients as enjoyable and helpful in skill development. Further,

simulated patients are thought to enhance student learning more than traditional methods of case discussion due to their highly interactive nature (Sistrunk, 2002).

### **1.3 Virtual Reality in Audiology**

There have been some reports of the use of simulation materials in audiology training programmes (Sistrunk, 2002; Johnson, Graham & Hsuch, 2006; Lieberth & Martin, 2005). For instance, students of Audiology typically have access to CD-ROMs and websites that provide information on vocabulary, sound propagation, hearing aid fitting, and the basic anatomy and physiology of the hearing mechanisms, but there is a lack of research into the usefulness of these as a means of developing clinical knowledge (Sistrunk, 2002). Typically, computer-based systems for clinical training of Audiology and Speech and Language Therapy students fall into one of three categories: simulation of diagnostic test procedures (audiometry and impedance only); patient simulation, where the patient's test-retest responses vary as a function of frequency, intensity and time; and programmed video playback of recordings of actual or re-enacted sessions (Slosberg & Levitt, 1978). Examples of each of these will be discussed below.

Simulation of diagnostic test procedures has been described by Johnson, Graham & Hsuch (2006), who developed a virtual audiometer for use in an introductory audiology course. This was found to help illustrate the theory behind the technique to students, actively engage students in the learning process rather than being passive receivers of knowledge, provide more practice opportunities for students, provide opportunities for the students to interact with one another and their tutors, and support meaningful student reflection. Similarly, Lieberth & Martin (2005)

found that basic audiometry skills could be learnt using a web-based audiometer for pure-tone testing only. They went on to specify that in order to be effective a web-based audiometer must be as true to life as possible, emulate the way a “real” patient would respond, provide feedback to the students as to the correctness of their technique, and that skills learnt on the simulator must be able to be generalised to the real thing.

AudSim (AudSim, 2008) is an interactive virtual audiometer utilising patient simulation that runs from a CD-ROM. The case history component involves selecting “view patient history” from a dropdown menu, which produces a short paragraph of the relevant history information. During audiometry, the simulator mimics a real patient by not always responding to stimuli at and above threshold and by varying the post-stimulus response times. In much the same way, The Audiology Clinic with Generator from Parrot Software simulates air and bone conduction audiometry with masking, and immittance measures – tympanometry and ipsilateral and contralateral reflexes. Twenty-five first year audiology students used this software to perform audiological assessment after taking a case history from a standardised patient (see glossary) then rated on a 5-point Likert scale how strongly they agreed/disagreed with statements about the impact of these interactions on various skills (Wilson, Hill, Hughes, Sher, & Laplante-Levesque, 2010). The students reported that interaction with the simulator and the standardised patient improved their abilities in all ten areas of client interaction: the ability to interact professionally and ethically, use of nonverbal communication techniques, use of verbal communication techniques, use of interpersonal skills, ability to obtain a case history, ability to use interviewing skills during the case history, ability to provide verbal feedback, ability to use interviewing



skills during the feedback, ability to confidently interact with patients, and to learn a new skill.

Programmed video playback of actual or re-enacted patient history information was incorporated into *Computer Simulated Testing (CST): Audiology* on CD-ROM. This was created and tested as a training tool for students by Sistrunk (2002). Nineteen first year Audiology students from three different Universities took part in evaluation of the software, which included basic audiometry as well as the video clips of patient history information. The case history component of this program involved the students asking questions by clicking a check box next to their desired question. The students expressed a desire for a more interactive component to be included in the software, and while all students surveyed did not feel that the program would be a necessary component of an Audiology course, they agreed that it had potential as a study and practice tool. Overall, they had a preference for the more traditional supervisor-student method of training.

#### **1.4 The Case History**

While the virtual audiometers described above have good student outcomes and are perceived to be a useful addition to traditional Audiology courses, not all of them include a case history component. The case history is a vital part of any basic audiological evaluation and involves gathering information about the patient's hearing loss or presenting complaint and determining all possible factors that may be contributing to it. It also provides valuable information about the patient's own view of their hearing. Those existing simulators that do include a patient history section are problematic in that students have identified the design as unrealistic. There is also

limited research into the effectiveness of these simulators over more traditional methods of student education.

It is important for students to practise extracting relevant information from the case history and integrating it with a patient's pure tone audiometry results in their differential diagnosis and management of a case, as mistakes at this early stage can severely hamper a patient's outcomes. Early development of good communication skills is also important as good patient-clinician communication leads to better clinical outcomes and more satisfied patients, while poor communication leads to poor outcomes and dissatisfaction (Coulehan & Block, 2001).

Interviewing skills were not part of most medical school curriculums until the 1970s, but rather it was expected that students would pick up these skills through observation (Coulehan & Block, 2001). Today, students are taught an ordered interview structure which goes through pre-determined stages, but they may deviate from this as more information is obtained from the patient (Dickerson, Johnsen, Raij, Lok, Hernandez, & Stevens, 2005). Interviewing skills are taught primarily through textbooks and lectures (Bickley, Szilagyi, & Stackhouse, 2002), or through the use of standardised patients (Dickerson et al., 2005). Standardised patients are actors playing the role of patients, or actual patients coached to present specific conditions (Hubal, Kizakevich, Guinn, Merino, & West, 2000).

A review of 69 English-language articles between 1996 and 2005 on the use of standardised patients in teaching and learning found that standardised patients were most commonly used for teaching communication skills (55%), then clinical skills (32%), then physical examination skills (17%) (May, Park, & Lee, 2009). Despite this, there is limited research into the efficacy of standardised patients as a training tool. Syder (1996) used standardised patients to develop clinical skills in three groups

of first and second year Speech and Language Therapy students, but this study did not look at the effectiveness of standardised patients as a teaching tool – only student perceptions.

## **1.5 Virtual Reality for Case Histories**

As an alternative to standardised patients, VR simulators can be used. Beyond the field of Audiology there are some VR simulators that incorporate a case history component. One such example is the web-based virtual patient program template developed by Zary, Johnson, Boberg, & Fors (2006) for medical, dental and pharmacy students. The case history component involved selecting questions to ask from a pre-prepared list, which is how many patient simulator programs function today. *Conversim* - the name for the voice-activated multimedia model of Interactive Drama Inc. – functions in this way, and allows for a conversation between a user and pre-recorded video responses. The user is prompted to speak a question from a list scrolling along the bottom of the screen, which the video recording then answers. It uses speech recognition to have a conversation with an expert in a particular field. Users of the software reported that they feel as if they are talking to a real person, that they enjoyed the experience, and that they became involved in the conversation (Harless, Zier, Harless, & Duncan, 2003).

Other simulators use free-field text input, while still others use natural speech and gestures as the input method. Bergin & Fors (2003) developed an interactive simulation of patient cases (ISP) for medical students which featured a video-based illness history-taking component using free text input, interactive physiological examination features, laboratory tests and user feedback. Development took over a

decade - the patient history function alone involved constructing a manuscript of around two hundred common questions and their corresponding answer for each case. 70 medical students evaluated the ISP and although they reported it could not answer all questions and did not understand all follow-up questions, 88-97% of the students thought that the ISP was of value in their studies. The authors acknowledged *“while the history taking function in natural language works acceptably well, there is, however, a need for improvement. The interpretation of natural language is a tricky business and collaboration with a team of linguists has been established”* (p. 374).

Dickerson et al., (2005) developed an immersive life-size virtual patient which seven medical students interacted with using natural speech and gestures. Student performance was measured based on the number of “core questions” that they asked – 7 out of 11 core questions were required to pass. The pilot study found that the virtual patient’s script matched only 60% of the student’s queries, but the students reported that the Virtual Interactive Character (VIC) – a virtual tutor to accompany the virtual patient and provide immediate feedback – was a key advantage of the simulator.

Other simulators include that reported by Hubal et al., (2000) which uses a 3-dimensional representation of a person developed for the training of patient history taking, and the VSP (Virtual Standardised Patient) which uses technology from the AVATALK<sup>TM</sup> Scripting Engine to enable users to take a case history from a virtual patient using natural speech (Hubal, Kizakevich, Guinn, Merino, & West, 2000). However, neither of these have yet been tested in real student courses (Bergin & Fors, 2003), nor is there any report in the literature of the usefulness or efficacy of this software.

## **1.6 Consideration of Simulation Efficacy**

While many VR simulations have limitations on realism, interactivity and applicability (Bergin & Fors, 1992; Good, 2003), studies of student perception of VR simulation software across the medical field have found that students report increased comprehension and memorisation of the subject matter after using the programs (Antonietti, Rasi, Imperio, & Sacco, 2000), and increased quality and quantity of practise (Johnson, Graham, & Hsuch, 2006). A review of the literature and surveys of accredited schools of physiotherapy found that simulated learning can enhance student's skills, confidence and competence (The Physiotherapy Consortium, 2010). Additionally, it has been found that students react similarly to real and simulated patients (HITLab NZ, 2011), and report high satisfaction (Rosen, McBride, & Drake, 2009) and motivation (Baillie & Percoco, 2000) with VR programs.

There are obvious challenges that arise with trying to emulate an authentic clinical situation as it is nearly impossible to capture all the nuances of real interactions, but one clear advantage of VR simulation over interactions with real patients is that there is no risk involved for the patient at all. This means that the learner does not have to stay within the 'zone of clinical safety' and can explore the limits of the procedures, thus enhancing their learning (Bradley, 2006; Kneebone, 2003; Marken, Zimmerman, Kennedy, Schremmer, & Smith, 2010). This also means that there is no liability risk to the students or the training institution. VR also allows for immediate feedback for the student as the patient is not waiting (Abrahamson & Wallace, 1980; Dickerson et al., 2005), so any issues, questions or clarifications can be discussed as they arise.

Standardised patients are often used in place of real patients, and although they can be useful as a training tool for students, human actors cost money for training, delivery and management, and may not be able to undergo all diagnostic tests (Hubal, Kizakevich, Guinn, Merino, & West, 2000; Dickerson et al., 2005). The advantage of VR simulation is that the virtual patient can be tested repeatedly by multiple students simultaneously and does not fatigue (Wilson, Hill, Hughes, Sher, & Laplante-Levesque, 2010).

VR simulation has its own costs associated with it though, including funding for development, set up and maintenance, purchase of materials, training of staff and students and employment of Information Technology specialists. There is also the cost of administrative and educator support, as well as the computers and associated hardware and software for development and use of the program (Theodoros, Davidson, Hill, & MacBean, 2010). Further, the use of VR requires educators to have adequate computer skills to develop new cases and to teach the students (Baillie & Percoco, 2000; Theodoros, Davidson, Hill, & MacBean, 2010). While traditional online training takes an average of 200 hours to create each hour of instructional content, online VR simulations require 750 to 1500 hours to create each hour of instructional content (Bell, Kanar, & Kozlowski, 2008; Summers, 2004).

These high initial costs mean that careful attention needs to be paid to program design (Huwendiek, et al., 2009). However, even with the best development and implementation new technology takes time to assimilate (Ziv, Small, & Wolpe, 2000), and not all students are comfortable learning from an inanimate object (Lieberth & Martin, 2005). Conversely, people tend to be attracted to the latest gadgets and technologies, and this enthusiasm and excitement can enhance the transference of the skills acquired from simulation training (Alinier, 2005). Although start-up costs may

be high, cost benefits may be smaller over a longer period of time when using VR compared with traditional teaching methods (Alinier, 2005).

While it was discussed earlier that increased classroom workloads place pressure on the curriculum and clinical placement time (Bergin & Fors, 2003), the use of VR simulation as a way of reinforcing what is taught in the classroom could decrease the amount of time needed to effectively cover the material (Sistrunk, 2002), thereby freeing up more time for clinical practice. Clinical educators reported that students who had more clinical knowledge and clinical skills resulted in a reduced workload and reduced time for them as an educator (Theodoros, Davidson, Hill, & MacBean, 2010).

Additionally, VR can be used to compensate for discrepancies between student experiences – patient cases can be created to demand (Bradley, 2006; Ziv, Small, & Wolpe, 2000) to ensure that all students see a wide range of different presentations and complaints and can gain experience with rare or specific cases that they may otherwise never encounter in their real clinical experiences over the course of their training programmes. More than this, supervisors can use VR simulations to give students a planned and gradual increase in the complexity of the cases presented (Abrahamson & Wallace, 1980) so that the student is always working within their zone of proximal development.

Simulators also have the potential to be used reliably to assess students in differential diagnosis, which frees up teaching time and resources. Research has shown that assessment outcomes on a computerised pediatric case simulator for medical students correlated with other standard measures of student performance (Feldman, Barnett, Link, Coleman, Lowe, & O'Rourke, 2006). It is important to note, however, that prior exposure to the simulator is necessary before it can be used as an

assessment tool (Morgan & Cleave-Hogg, 2000), which in itself can be time-consuming and this may outweigh the time-saving benefits of VR assessment. Additionally, problems can occur when the program steers the user in a particular direction so that they are unable to collect all the information that they wanted to (Round, Conradi, & Poulton, 2009).

The Physiotherapy Consortium (2010) identified some barriers to the use of VR simulations with physiotherapy students, including a lack of funding for simulation resources. A lack of available simulation facilities, technical support and training programmes for students and clinical educators in simulated learning also contributed. If these barriers can be overcome, however, outcomes for student learning through VR use can be very good.

Rosen, McBride & Drake (2009, p.842) define learning as “*an active process which demands the implementation of student-centred, interactive teaching methods*”. The use of 3-D imagery in VR training tools can enhance student learning by eliminating the loss of detail that occurs when information is printed in books or on slides, and the animation of complex structures can allow the student to feel as though they are manipulating complex organs (Sistrunk, 2002). Additionally, VR enables learning in a safe environment at the learner’s own pace (Abrahamson & Wallace, 1980; Alinier, Hunt, Gordon, & Harwood, 2006; Kneebone, 2003), and enables the student to determine their own training agenda based on their strengths and weaknesses. This encourages critical self-reflection and allows students the chance to modify their behaviour prior to their clinical placements.

Because simulation is not dependent on the availability of anyone but the user, students are not limited by the time of day or their physical location when wanting to practise (Zary, Johnson, Boberg, & Fors, 2006). This also means that students can use



the simulator to practise their clinical skills over the holiday period or while the University campus is closed, thus maintaining their skills and cutting down on the practice time required upon their return to study. Web-based VR simulation can be accessed from any platform (Windows, Linux, Unix, Mac OS etc.) and can handle many user requests at the same time. One further advantage of this method of delivery is that the users do not have to upgrade or maintain the software as it is all managed on the server machine (Zary, Johnson, Boberg, & Fors, 2006).

Overall, the potential benefits of simulation training appear to outweigh any contraindications. Theodoros, Davidson, Hill & MacBean (2010) surveyed ten universities across Australia, four of which used simulated learning environments (SLEs) - including standardised patients, low fidelity mannequins and environmental simulations - for teaching Speech and Language Therapy students and identified some strengths and weaknesses of these approaches. While the use of SLEs aided the development of clinical competencies prior to entering the workforce, there was uncertainty regarding the recognition of SLEs as evidence of competency in the accreditation process and some concern that SLEs may be used as part of the rationale to reduce the availability and/or funding of clinical practicum placements in the future. VR's role in Audiology is not considered a replacement for real clinical experience, but rather as complementary to the existing educational model. VR use may only be suited to the early stages of clinical education (Theodoros, Davidson, Hill, & MacBean, 2010), but this does not decrease its potential value.

## **1.7 Rationale for the Current Study**

Hearing loss is a common problem with a variety of causes. With the proven benefits of early identification of hearing loss in children, and New Zealand's rapidly ageing population there is an on-going need for more audiologists to be trained. Current training programmes are comprised of lectures and coursework and involve clinical practice in a range of different settings. However, there are financial and practical limitations on student access to these. Given the limitations of the current educational model, there is a need for alternative teaching methods to be explored.

One such option is the inclusion of virtual reality into the current educational framework. Virtual reality in education has been around for over 50 years, and in order to provide students with more comprehensive clinical experiences patient simulators have been developed. While several audiometry simulators are described in the literature, there is a lack of published data on the inclusion of a highly interactive case history component in these simulators. Additionally, there is little conclusive evidence beyond student perception that these programs are of equal or more benefit to student education than traditional education approaches. Objective evidence is needed to show whether or not simulation can benefit learning.

This poses the question – would a more comprehensive and interactive virtual patient result in greater, more defined gains in student learning? The following study seeks to answer this question.

The specific aims of the study were:

1. To develop a new virtual audiometry package that includes a highly interactive case history component;
2. To determine whether or not audiology students perform better on case history tasks following training on this new software than when learning using traditional clinical education methods alone; and
3. To investigate student perceptions of this new software.

To accomplish this, twelve first year Master of Audiology students were recruited to take part in a training programme of alternating treatment design across groups. Students were evaluated on their accuracy, confidence and efficiency when taking a case history from a standardised patient in order to determine whether or not the skills acquired will generalise to interactions with a real patient. It was hypothesised that the students would show significant improvements in these areas following simulator use. Standardised patients are commonly used clinically as an assessment tool (May, Park, & Lee, 2009), and in this case were used for assessment in place of real patients for practical reasons – a scripted patient allows for consistency between each participant's assessments. Along with the evaluation measures described above participants were required to report on the amount of recent clinical experience they had with real clients. This acted as a control to ensure that any between-group differences observed at each assessment point could be attributed to simulator use rather than recent practical experience.

## **1.8 Hypotheses**

It is hypothesised that students will show significant improvements in accuracy, confidence and efficiency following training on this new software, with a significant difference between groups in these scores observable at the mid-way assessment point. Additionally, it is hypothesised that there will be no significant difference in experience scores between groups.

It is expected that gains in accuracy will be observed following training as students report increased comprehension and memorisation of subject matter following training with simulation software (Antonietti, Rasi, Imperio, & Sacco, 2000). Greater gains are expected to be observed in verbal accuracy scores than written accuracy scores as the software does not specifically teach written recording skills. The Physiotherapy Consortium (2010) reported that simulated learning can enhance student's confidence and competence, and similar improvements in confidence and efficiency are expected here. Students are expected to experience a similar quantity and range of clinical situations throughout the course of their training, so no difference in Experience scores between groups is expected.

## **2 Method**

### **2.1 Participants**

Twelve first year audiology students were recruited from the University of Canterbury Master of Audiology Programme to take part in this study. Ethical approval from the University of Canterbury Human Ethics Committee was obtained for the experimental protocol and informed consent was also obtained for each participant (see Appendix I). Three males and nine females took part, aged between 22 and 55 years, with a mean of 33 years ( $SD = 11.41$ ). All participants held at least a Bachelor's Degree, with two reporting a Master's degree and one a PhD as their highest level of tertiary qualification. Nine participants were native speakers of English, while Chinese and German were reported as the native languages for the other three participants. Five participants were born in New Zealand and seven were born overseas. Of those seven, they had spent a mean 11.79 years in New Zealand ( $SD = 7.64$ ). All twelve participants were deemed to have sufficient English language written and oral skills to be admitted into a New Zealand postgraduate programme. Ten participants reported having normal hearing while one had a mild bilateral high-frequency noise-induced hearing loss and another had a bilateral mild to moderate sensorineural hearing loss from birth. Eight of the participants required glasses to use the computer, but all deemed their vision and hearing adequate for simulator use. All participants received equal financial reimbursement (NZ\$50 petrol voucher) for their participation in this study. All participation and data collection took place in the second half of the academic year.

Eleven of the students were enrolled full-time, with one student enrolled part-time. All students had completed courses in Clinical Audiology, Biological Bases of Auditory Function, Acoustics and Psychoacoustics, and Amplification prior to testing, and in addition had completed or were completing courses in Pediatric Audiology, Research Design, Electrophysiological Techniques, Advanced Audiological Assessment, Cochlear Implants and Aural Rehabilitation during the testing and training periods. All students were enrolled in the Clinical Observation and Practice course at the University of Canterbury at the time of testing. This course involves one day per week of clinical observation and practical experience at audiology clinics around Christchurch.

## **2.2 The Patient Simulator Program**

The virtual reality program used in this study is referred to as the Patient Simulator Program. The Patient Simulator Program (PSP) was developed at the Human Interface Technology Laboratory New Zealand (HIT Lab NZ) at the University of Canterbury.

The PSP is based on a simulation platform initially developed by the University of Florida's Virtual Experiences Research Group (University of Florida, 2011). This group aims to develop experiences with virtual humans for healthcare students and professionals, with a focus on Human – Virtual Patient interactions.

This platform was then used as a basis for the Immersive Learning Project, which is conducted at the HIT Lab NZ, and is part of a separate PhD research project.

In the case of the PSP, the initial platform was adapted in a .NET software environment using C# programming language. The objective was to foster

communication skills and to incorporate and train domain specific skills and decision-making. This aimed to simulate the standard audiological test battery including history taking, pure tone audiometry, otoscopy, speech audiometry (implementation in progress) and pathology diagnosis. These components were implemented as a common effort from the developer and audiology experts in order to best suit the need of trainee audiologists and supplement their learning.

### **2.2.1 Software Development**

Development of the program content took place over two phases. Phase One involved the development of audiograms, collection of otoscopic images and generation of a brief summary of case history information for 25 individual cases that were devised and outlined by the Clinical Coordinator of the Master of Audiology programme at the University of Canterbury. Phase Two involved the development of comprehensive case histories for the 25 virtual patients and identification of triggers for eliciting each piece of case history information from the virtual patient.

### **2.2.2 Phase One**

Brief case history summaries were generated by the author for each of the 25 cases (see Appendix II) based on clinical experience and information from textbooks and recent journal articles, and these were checked for accuracy and approved by the Clinical Coordinator before being entered into the program. Each of these cases was also assigned audiometric and otoscopic information consistent with the case history

information. This was conducted by another Master of Audiology student as part of a separate research dissertation.

### **2.2.3 Phase Two**

#### **2.2.3.1 *Case History Development***

The existing 25 case history summaries were expanded into comprehensive lists of patient characteristics (provided in Appendix III) based on the categories of the standard Diagnostic Adult History Form used clinically at the University of Canterbury<sup>1</sup> (see Appendix IV). To develop the 25 case histories for the software, generic answers were created for each of the following categories: balance/vertigo, ENT history, facial numbness/weakness, family history, feeling of fullness or pressure in ears, general communication difficulties, health questions, hearing in 1:1 vs. groups, hearing in quiet situations vs. background noise, noise exposure, occupation, previous hearing aid use/hearing tests, reason for referral, hearing on the telephone, hearing the television/radio, tinnitus, and the patient's view of their hearing. Each case included at least one answer from each category. The resulting cases were checked for accuracy and authenticity, and approved by an experienced clinical audiologist. The virtual patient's answers were generated using the OpenMary text-to-speech interface (DFKI, 2010), which is an open-source software that allows users to create audio files of speech from text. The audio output can be set to match different male and female voices, which facilitated creation of the necessary sound files for the simulated interviews.

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<sup>1</sup> This form was originally developed in 2005 at the University of Canterbury, and underwent further revisions between 2005 and 2008.



#### **2.2.3.2      *Trigger Selection***

In order to inform the investigator's development of the case history portion of the PSP, second year and recent graduate audiology students from across New Zealand were invited to complete a survey regarding how they phrase their questions when conducting a case history interview (see Appendix V). Seven recent graduates (all female) and seven second year students (one male, six female) responded, and their questions were collated and combined with those asked by the study's participants in the initial assessment (described later). This data was then processed through the Virtual People Factory's (University of Florida, 2011) interface by the software programmer in order to determine the key words and phrases typically used to elicit each piece of information.

Once these triggers were identified, testing of the software by five second-year Master of Audiology students took place over a period of two weeks. Testers were asked to attempt to obtain a comprehensive audiologic history from a number of the virtual patient cases while using the standard Diagnostic Adult History Form used clinically as a prompt. Any incorrect, inconsistent or absent responses from the virtual patient were recorded, and changes to the triggers in the software for each case were adjusted accordingly based on this feedback. Additionally, testers were required to evaluate the audio recordings for each of the virtual patient's responses and identify any incorrect, inconsistent or absent recordings, and adjustments were made to the program to accommodate the identified problems.

### **2.2.3.3      *Design Consideration***

Master of Audiology students who may or may not have a clinical background in other related fields were the target audience for this new software. It is expected that audiology students have at least a basic level of computer skills and it was hoped that they were able to operate the program unassisted, in their own time.

## **2.3      Participant's Task**

Participants were required to take part in a baseline test where they were asked to obtain an audiological case history from a standardised patient (role-played by a second year Master of Audiology student) and record their findings on a lined A4 piece of paper. They were then required to participate in a two-week training period with the PSP, and undergo two further assessment sessions where they again obtained a case history from a different standardised patient. Multiple assessment sessions were required for the alternating treatment design across groups, as described in the *Procedures* section.

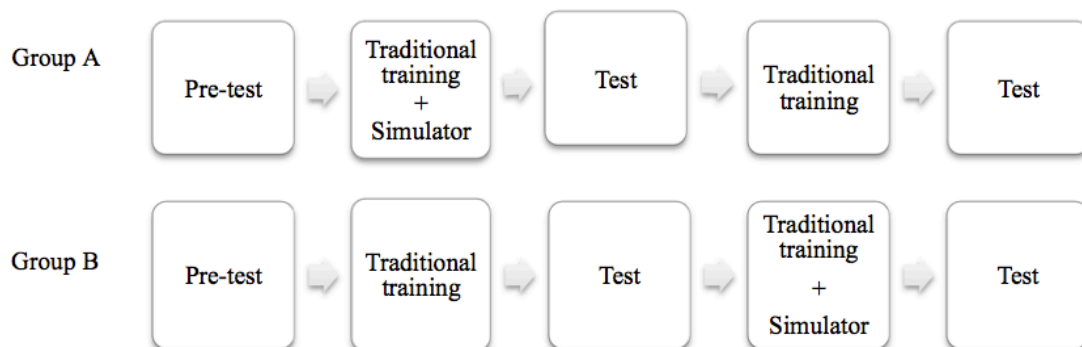
## **2.4      Equipment**

Audio recordings during each testing phase were made using the *Voice Memos* application of an iPhone 4. This produced AAC audio files with a bit rate of 64 kilobits per second (kbps) and a sample rate of 44.100 kHz. The audio recordings were used to check any discrepancies that may have arisen between the two markers for verbal accuracy scores.

Participant training with the simulator took place on computers running Microsoft Windows XP or higher, with a minimum 2.3 GHz processor, 2-4 GB memory, and a Graphics Card with a minimum of 256MB of RAM. These computers were located in the Department of Communication Disorders Postgraduate computer suite, which the participants had access to at all times.

## 2.5 Procedures

This study involved an alternating treatment design across groups (see Figure 1). Participants took part in a pre-test where they were asked to obtain an audiological case history from a standardised patient. Based on their scores for accuracy, experience, confidence and efficiency, the participants were assigned to one of two groups (Group A and Group B).



**Figure 1.** Alternating treatment design across groups

It was originally planned that one month following the pre-test (after University holidays), Group A would begin a three-week training period with the PSP. However, due to delays in the programming of the software, this was postponed by seven weeks, resulting in an eleven-week gap between the pre-test and the

commencement of training. Because of this delay, the time that the participants were able to spend training with the PSP was shortened to two weeks. Group A participated in traditional classroom training plus the PSP (virtual reality or VR condition) for two weeks while Group B participated in traditional classroom training only. At the end of this training period, participants were again assessed on their ability to collect an audiological case history. For the next two-week period Group B took part in the VR condition while Group A took part in traditional classroom training, following which a final assessment of case history taking skills took place.

### **2.5.1 Test Environment**

Each phase of testing was conducted in a sound-treated clinical room that is routinely used for audiological testing in the soundfield at the University of Canterbury. The participant was seated directly facing the standardised patient, with the recording device placed on a chair between them. The primary examiner was seated at a 45° angle to the participant's left. No other people were present in the room at the time of testing.

### **2.5.2 Instructions**

Prior to beginning testing, each participant filled in a questionnaire (provided in Appendix VI) to establish his or her pre-test experience and confidence scores. The participants were then given a pen and a blank sheet of lined paper on a clipboard, and instructed to take a case history from the standardised patient seated in front of them, just as they would in clinical practice. They were instructed to record the information obtained on the provided sheet of paper in a format that they deemed suitable for clinical use. It was noted that standard clinical abbreviations would be accepted on the

written part of the task. The primary examiner then introduced the standardised patient with the carrier phrase “*This is \_\_\_\_\_. He/she is \_\_\_\_\_ years old and has come into your clinic to see you today*”.

Once the participant indicated they were finished taking the case history, they each filled in a further questionnaire (see Appendix VI) to establish their post-test confidence scores, review their own performance and identify a possible type, severity and configuration of hearing loss that they may expect from the patient given the information obtained. Feedback from the primary examiner and standardised patient was then given, letting the participant know if there were any patient characteristics they did not ask about.

For those participants who had just completed the two-week training period, an additional questionnaire (see Appendix VII) was administered to obtain feedback on their use and opinions of the PSP. The bulk of the opinion information was collected on behalf of the PhD student to inform his research. Information regarding use of the software was collated and analysed.

The standardised patient was given a separate list of patient characteristics (provided in Appendix VIII) for each of the three assessment sessions, and instructed to answer the participant’s questions with only one piece of information on the list at a time. If the participant asked a question that did not have an answer on the list, the standardised patient was instructed to give a vague answer such as “*I don’t know*”, “*I haven’t really thought about that before*” or “*I can’t remember*”. The standardised patient was asked to tick each piece of information off the list as they said it as a cross-check for the marking performed by the primary assessor.

### **2.5.3 Training Phase**

Three days prior to the commencement of the VR condition, participants were emailed instructions on how to use and a screenshot of the PSP. All participants verbally consented to a minimum of two hours practice with the simulator prior to the testing session, and were explicitly encouraged to attempt to complete all 25 cases. Six computers were made available 24 hours a day in two distinct locations at the university, and headphones were provided for participants if they wished to use them. A tutorial was offered to all participants in addition to the written instructions, but only one participant opted to take part. The standard adult case history forms used in the University of Canterbury clinic were provided for the students to use to prompt them during training if they wished. Halfway through the training period, each participant was emailed to remind them that they had committed to minimum of two hours practice with the PSP but completion of all 25 cases was ideal. Participants were given the option of completing each case in its entirety (otoscopy and audiometry in addition to the case history) but were instructed that the time they spent on these other two components would not be included in the two hour minimum specified. The following instructions were emailed to each participant prior to the commencement of their training phase:

1. Ask only one question at a time
2. Refrain from making statements
3. If the patient does not understand your question, try rephrasing the question – and double-check that you were not trying to ask two or more things at once
4. Double-check your spelling, the patient will not understand abbreviations or spelling errors

5. The patient will always try to answer your question to the best of its ability – it's not trying to trick you. Therefore if it asks you to repeat your question it's not because it is pretending to have misheard you
6. If you find that the patient is not responding to a question that you need the answer to, try making your language less specific
7. Alternatively, questions such as “can you describe that?” will not give a response either, and you'll need to be MORE specific

Participants were also sent the following screenshot of the program to help guide them (Figure 2).



**Figure 2.** Explanatory Screenshot of the Patient Simulator Program (PSP) sent to participants prior to commencement of training

#### **2.5.4 Measurements**

Measures were taken from the pre- and post-test questionnaire, verbal transcripts of each case history, and the written notes that each participant recorded during each interview. Participants were assessed on their accuracy, clinical experience, confidence and efficiency, and were marked by two assessors. Additionally, participant responses on their use of the software were analysed. Each of these is discussed below.

##### **2.5.4.1 Accuracy**

Accuracy measures were derived from the verbal transcripts of each case history and the written notes that each participant produced. Two distinct categories of accuracy were evaluated – verbal accuracy, and written accuracy.

Verbal accuracy raw scores were determined based on the number of patient characteristics that the participants were able to obtain from the standardised patient during the case history interview, out of a possible 43 items. Marking took place during the case history interview by both the standardised patient and the primary assessor.

Written accuracy raw scores were determined based on the number of patient characteristics that the participant correctly wrote down on the paper provided. Items were marked as correct if the assessor deemed that another audiologist who had not met the patient would understand what was written. If the assessor deemed that an item had been recorded incorrectly one mark was deduced per item from the total written score. Half marks were awarded if an item was recorded incompletely - where the assessor deemed that most of the key information was there but some minor detail was missing.



#### **2.5.4.2      *Experience***

In order to monitor and control for the effects of clinical experience outside the simulator on case history taking performance, participants completed a post-test questionnaire requiring them to respond by ticking a checklist of their clinical experiences (see Appendix VI). For data entry and statistical analysis, the response categories were numerically coded with different weightings for each question depending on their perceived impact on history taking performance as follows:

*“The last time I conducted a case history interview under supervision was:”*

0 = Never, 6 = Within the last 3-4 days, 5 = Within the last 5-7 days, 4 = between 1 and 2 weeks ago, 2 = over two weeks ago

*“The last time I observed a case history interview was:”*

0 = Never, 4 = Within the last 3-4 days, 3 = Within the last 5-7 days, 2 = Between 1 and 2 weeks ago, 1 = Over three weeks ago

*“How many clinics have you observed and/or participated in case history taking at?”*

1 = None, 2 = One, 3 = Two, 4 = Three, 5 = Four or more. These numbers were then added together to give an overall score for experience.

#### **2.5.4.3      *Confidence***

Confidence scores were derived from the pre- and post-test questionnaires, and relied on a 7-point Likert-rating scale evaluating the participant's own anxiety levels, confidence and preparedness. Measures were taken pre- and post-test to provide an average score for each of these measures. These were then totalled and averaged to provide an overall confidence score. The anxiety scale was negatively phrased (e.g. lower score = less anxiety; whereas a lower score = less confident/less

prepared for measures of confidence and preparedness) so anxiety scores were reversed for analysis, i.e. 1 = highly anxious, 7 = not anxious at all.

#### **2.5.4.4        *Efficiency***

Efficiency scores were derived from the total number of questions asked divided by the number of patient characteristics obtained verbally (verbal accuracy raw score). The lower the resulting score, the more efficient a participant's questioning was considered. Excluded from the question count were comments made by the participants and questions directed towards the primary examiner rather than the standardised patient.

#### **2.5.4.5        *Self-Report Measures***

Participants were required to report approximately how long they spent practicing with the software, how many different cases they attempted, and to identify whether or not they attempted the same case more than once. Additionally, they were asked to identify negative and positive aspects of the software, factors that prevented or discouraged them from using the software and to identify factors that might have encouraged them to use the software more. Finally, each participant rated the perceived usefulness of the software as a tool for practicing case history taking on a 7-point Likert scale.

## **2.6 Group Distribution**

Once scores for each of the above measures were determined, participants were given an overall ranking for each and sorted into one of two performance-matched groups based on these results. An overall ranking for accuracy was determined by combining the percentage verbal score (raw verbal score/total items) with the percentage written score (raw written score/raw verbal score). Groups were gender matched where possible.

### **2.6.1 Group Assignment**

Based on the pre-test scores for accuracy, experience, confidence and efficiency, the participants were assigned to one of two groups: Group A and Group B. However, one participant in Group B failed to follow instructions regarding the timing and duration of simulator use, so their data has been excluded from that reported below.

Group A consisted of 5 females and 1 male, while Group B was made up of 4 females and 1 male. Table 1. presents a summary of the demographic information for Group A and Group B as well as for the participant group as a whole.

<b>Table 1.</b> Demographic information for all participants, as well as Group A and Group B			
	All Participants (N = 11)	Group A (N = 6)	Group B (N = 5)
<b>Mean Age (years)</b>	31.00	28.67	33.80
<i>Standard Deviation</i>	9.51	6.89	12.19
<b>Mean Clinical Experience (years)</b>	1.91	2.5	1.2
<i>Standard Deviation</i>	2.47	3.02	1.64
<b>Mean Self-Rated Computer Skills</b>	2.27	2.00	2.6
<i>Standard Deviation</i>	0.65	0.63	0.55

An independent t-test showed that Group A was not significantly younger than Group B ( $t(9) = 0.882$ ,  $p = 0.401$ ), did not have significantly more clinical experience ( $t(9) = 0.858$ ,  $p = 0.272$ ), and did not rate their computer skills as significantly greater or poorer ( $t(9) = 1.662$ ,  $p = 0.131$ ).

Mean scores and standard deviations for all measures at the initial assessment are displayed in Figures 3 - 7. The scores for Group A and Group B were compared using an independent t-test and no significant difference was found in written scores ( $t(9) = 0.593$ ,  $p = 0.568$ ), verbal scores ( $t(9) = 0.057$ ,  $p = 0.955$ ), experience scores ( $t(9) = 0.138$ ,  $p = 0.893$ ), confidence scores ( $t(9) = 0.279$ ,  $p = 0.786$ ), or efficiency scores ( $t(9) = 0.003$ ,  $p = 0.998$ ).

## **2.7 Reliability**

Development of the 25 virtual patient cases was checked and approved by an experienced clinical audiologist based externally to the University of Canterbury. Two assessors with clinical experience in audiology approved the three patient characteristics lists as being representative of standard case history responses. Both the primary assessor and the standardised patients marked for verbal accuracy independently, and a reliability score was determined. Audio recordings were made of each interview in case any discrepancies in marking arose.

## **2.8 Statistical Analysis**

Data for each participant was collected in a Microsoft Excel spreadsheet and group means and standard deviations were calculated. All further data analysis was completed using The Statistical Package for the Social Sciences (SPSS).

Between-group means were compared using an independent t-test, and within-group progress was compared using a 1-sample t-test. Changes in scores over time were compared between groups using a series of one-way analysis of variances (ANOVAs). A significance value of  $p \leq .05$  was used throughout.

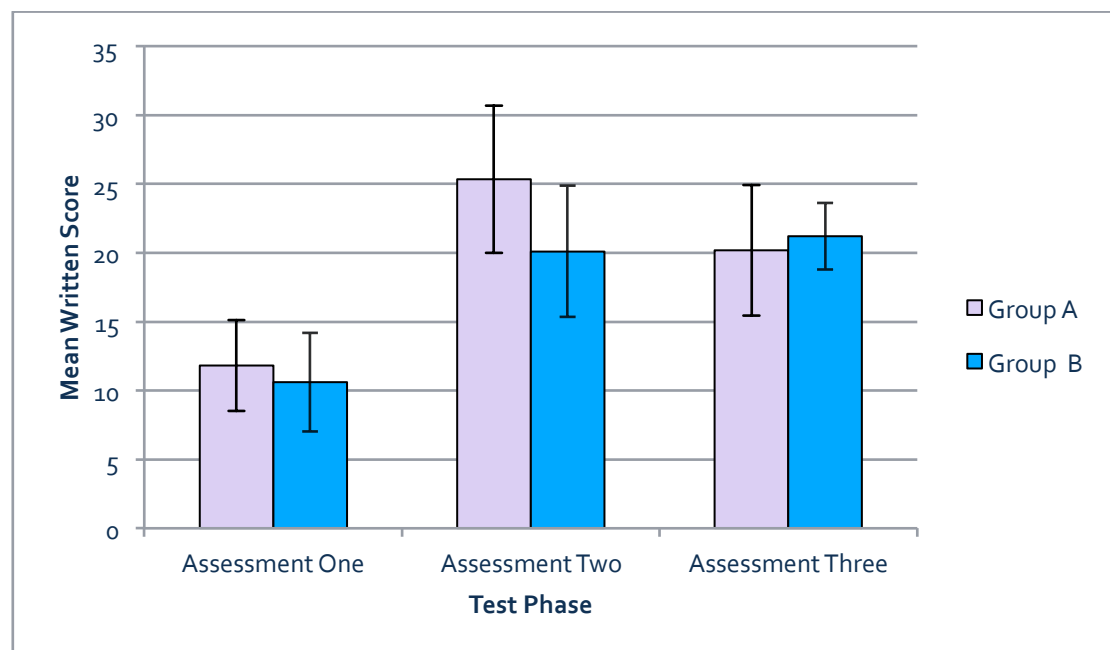
### **3 Results**

Analysis of the participant's scores and self-report measures is presented below. This was conducted in order to a) determine whether or not audiology students perform better on case history tasks following training on the new patient simulator program than when learning using traditional clinical education methods alone, and b) investigate student perceptions of this new software. The data is presented in two sections with the quantitative data first: accuracy scores (written and verbal), experience scores, confidence scores, and efficiency scores; followed by qualitative and quantitative data from the participant's self-report measures.

### 3.1 Accuracy

#### 3.1.1 Written Score

Mean written scores and standard deviations for Group A and Group B across all three test phases are shown in Figure 3. Significant differences between groups are marked with an asterisk.



**Figure 3. Mean written scores of Group A (n=6) and Group B (n=5) at each of the three test phases (assessment one, assessment two, and assessment three).**

**Vertical bars show standard errors of the mean.**

#### *Between Group Differences*

Written scores for Group A and Group B were compared using an independent t-test and no significant difference was found between the groups at both the second ( $t(9) = 1.697$ ,  $p = 0.124$ ) and third ( $t(9) = 0.440$ ,  $p = 0.671$ ) assessment points.

Analysis of variance between groups was performed, and no significant difference was found at the first [ $F(1, 9) = 0.352, p = 0.568$ ], second [ $F(1, 9) = 2.879, p = 0.124$ ] or third [ $F(1, 9) = 0.193, p = 0.672$ ] assessment points.

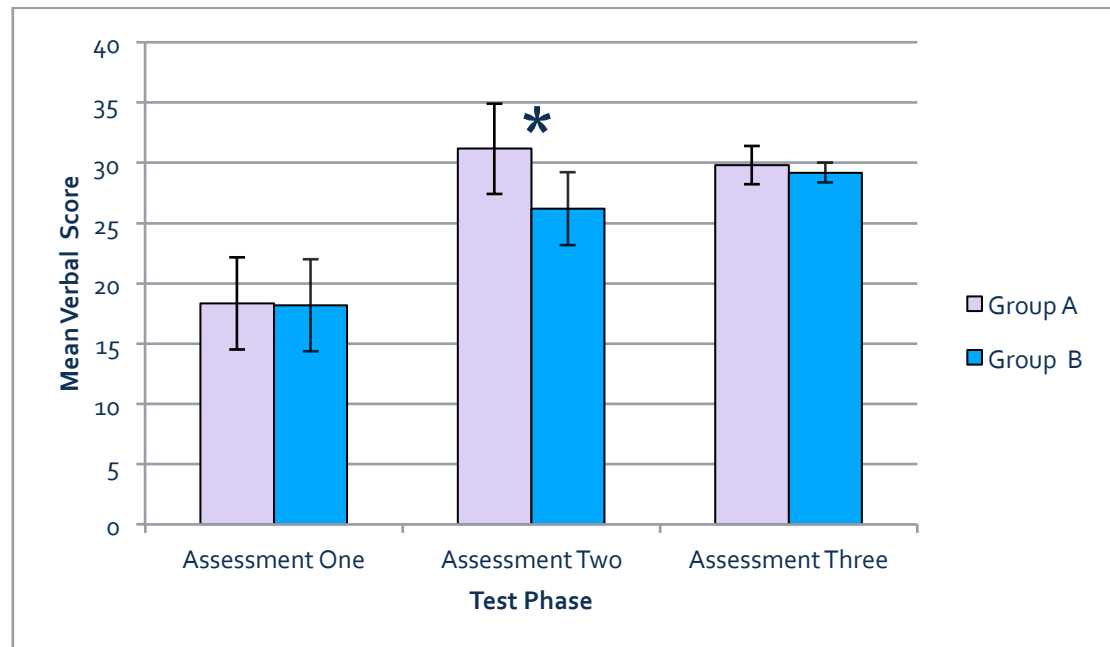
#### *Within Group Differences*

Both Group A ( $t(10) = 3.859, p = 0.003$ ) and Group B ( $t(8) = 2.455, p = 0.039$ ) showed significant improvements in written scores from assessment one to assessment two, but while Group B showed no significant change from assessment two to assessment three ( $t(8) = 0.381, p = 0.713$ ) Group A's written scores significantly decreased ( $t(10) = 2.311, p = 0.043$ ). Both Group A ( $t(10) = 2.850, p = 0.017$ ) and Group B ( $t(8) = 6.477, p = <0.005$ ) showed significant improvements in written scores from assessment one to assessment three.



### 3.1.2 Verbal Score

Mean verbal scores and standard deviations for Group A and Group B across all three test phases are shown in Figure 4. Significant differences between groups are marked with an asterisk.



**Figure 4. Mean verbal scores of Group A (n=6) and Group B (n=5) at each of the three test phases (assessment one, assessment two, and assessment three).**

**Vertical bars show standard errors of the mean.**

#### *Between Group Differences*

Verbal scores for Group A and Group B were compared using an independent t-test and a significant difference was found between the groups at the second assessment point ( $t(9) = 2.372$ ,  $p = 0.042$ ), with no significant difference found at the third and final assessment point ( $t(9) = 0.794$ ,  $p = 0.448$ ). Analysis of variance between groups was performed, and a significant difference was found between the groups at the second assessment point [ $F(1, 9) = 5.625$ ,  $p < 0.02$ ]. No significant

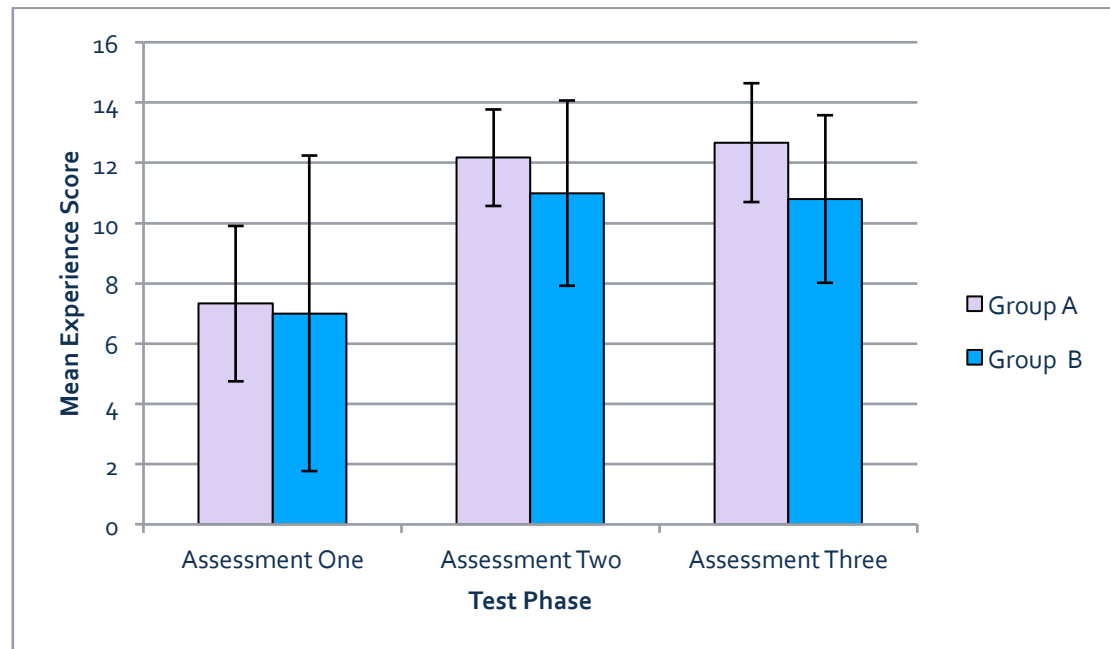
difference between groups was found at the first [ $F(1, 9) = 0.003, p = 0.955$ ] or final [ $F(1, 9) = 0.630, p = 0.448$ ] assessment point.

#### *Within Group Differences*

Both Group A ( $t(10) = 5.245, p = <0.005$ ) and Group B ( $t(8) = 2.375, p = 0.045$ ) showed significant improvement in verbal scores from assessment one to assessment two. Neither Group A ( $t(10) = 1.224, p = 0.249$ ) nor Group B ( $t(8) = 2.230, p = 0.058$ ) showed significant change in verbal scores from assessment two to assessment three, but both groups showed significant improvements in verbal scores from assessment one to assessment three: Group A ( $t(10) = 5.238, p = <0.005$ ), Group B ( $t(8) = 6.268, p = <0.005$ ).

### 3.2 Experience

Mean experience scores and standard deviations for Group A and Group B across all three test phases are shown in Figure 5. Significant differences between groups are marked with an asterisk.



**Figure 5. Mean experience scores of Group A (n=6) and Group B (n=5) at each of the three test phases (assessment one, assessment two, and assessment three).**

**Vertical bars show standard errors of the mean.**

#### *Between Group Differences*

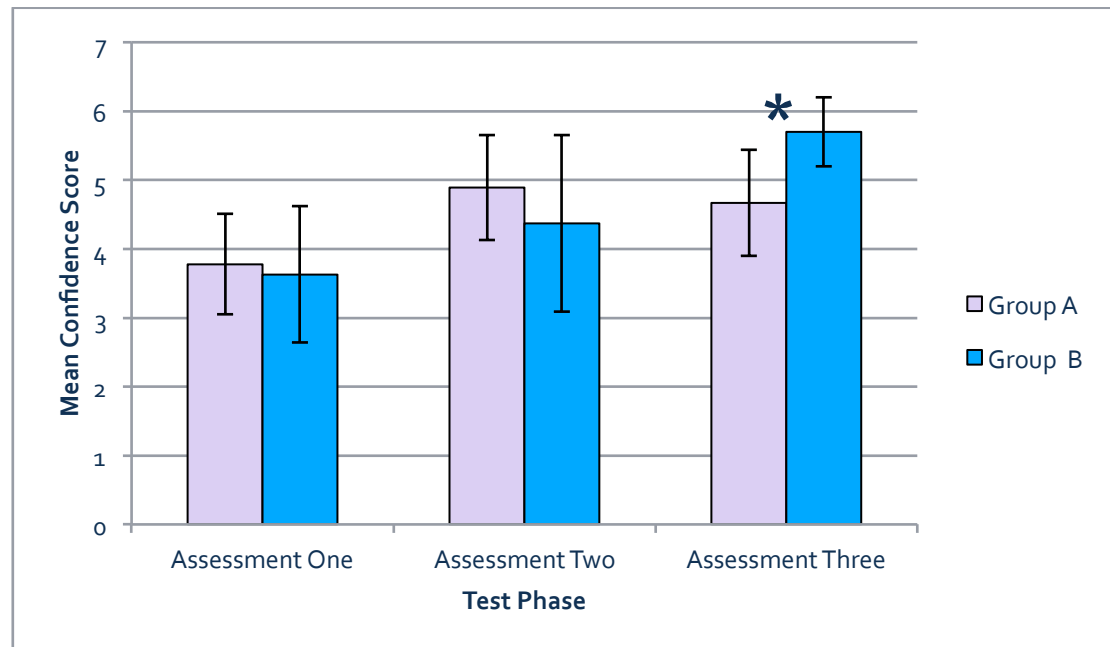
Experience scores for Group A and Group B were compared using an independent t-test and no significant difference was found between the groups at both the second ( $t(9) = 0.811$ ,  $p = 0.439$ ) and third ( $t(9) = 1.306$ ,  $p = 0.224$ ) assessment points. Analysis of variance between groups was performed, and no significant difference was found between groups at the first [ $F(1, 9) = 0.019$ ,  $p = 0.893$ ], second [ $F(1, 9) = 0.657$ ,  $p = 0.438$ ] or third [ $F(1, 9) = 1.706$ ,  $p = 0.224$ ] assessment points.

### *Within Group Differences*

Group A showed a significant increase in experience scores from assessment one to assessment two ( $t(10) = 3.073$ ,  $p = 0.012$ ) and assessment one to assessment three ( $t(10) = 2.886$ ,  $p = 0.016$ ), with no significant change from assessment two to assessment three ( $t(10) = 0.483$ ,  $p = 0.640$ ). Group B showed no significant increase in experience scores from assessment one to assessment two ( $t(8) = 1.842$ ,  $p = 0.103$ ), from assessment two to assessment three ( $t(8) = 0.103$ ,  $p = 0.920$ ), or from assessment one to assessment three ( $t(8) = 1.529$ ,  $p = 0.165$ ).

### 3.3 Confidence

Mean confidence scores and standard deviations for Group A and Group B across all three test phases are shown in Figure 6. Significant differences between groups are marked with an asterisk.



**Figure 6. Mean confidence scores of Group A (n=6) and Group B (n=5) at each of the three test phases (assessment one, assessment two, and assessment three).**

**Vertical bars show standard errors of the mean.**

#### *Between Group Differences*

Confidence scores for Group A and Group B were compared using an independent t-test and no significant difference was found between the groups at the second assessment point ( $t(9) = 0.849$ ,  $p = 0.420$ ). A significant difference was found, however, at the third assessment point ( $t(9) = 2.584$ ,  $p = 0.030$ ). Analysis of variance between groups was performed, and there was no significant difference between groups at either the first [ $F(1, 9) = 0.078$ ,  $p = 0.786$ ] or second [ $F(1, 9) = 0.714$ ,  $p =$

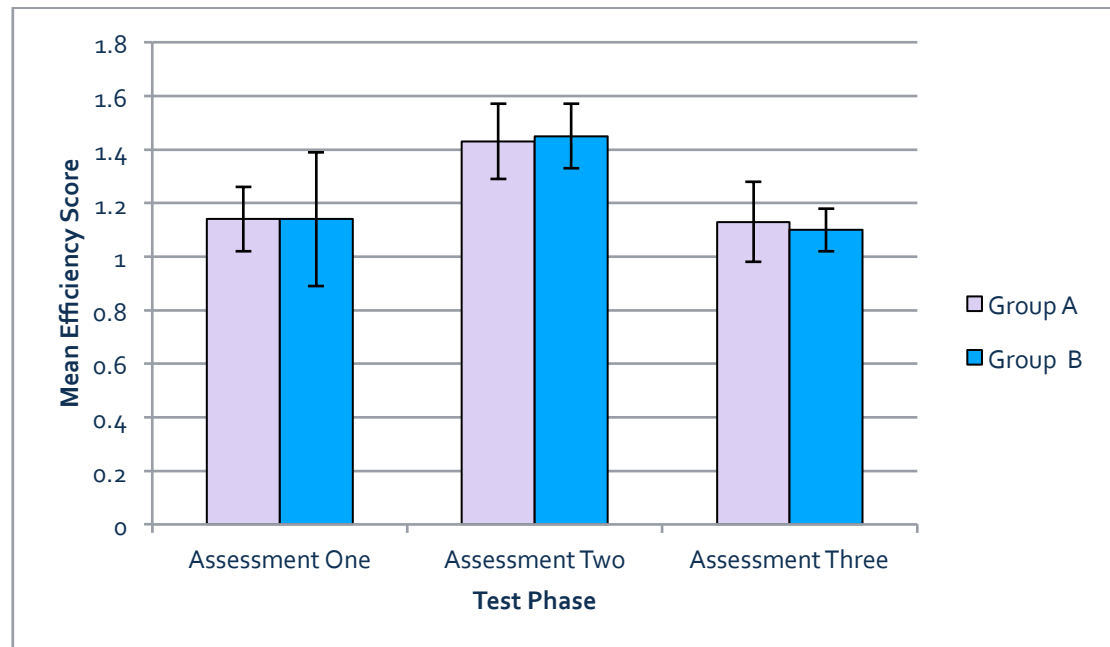
0.420] assessment points. There was a significant difference between groups at the third assessment point [ $F(1, 9) = 6.678, p = 0.029$ ].

#### *Within Group Differences*

Group A significantly increased in confidence from assessment one to assessment two ( $t(10) = 3.617, p = 0.005$ ) and from assessment one to assessment three ( $t(10) = 3.340, p = 0.007$ ), but there was no significant change in confidence from assessment two to assessment three ( $t(10) = 0.357, p = 0.728$ ). Group B did not significantly increase in confidence from assessment one to assessment two ( $t(8) = 1.458, p = 0.183$ ), or from assessment two to assessment three ( $t(8) = 2.175, p = 0.061$ ), but there was a significant improvement in confidence from assessment one to assessment three ( $t(8) = 4.953, p = 0.001$ ).

### 3.4 Efficiency

Mean efficiency scores and standard deviations for Group A and Group B across all three test phases are shown in Figure 7. Significant differences between groups are marked with an asterisk.



**Figure 7. Mean efficiency scores of Group A (n=6) and Group B (n=5) at each of the three test phases (assessment one, assessment two, and assessment three).**

**Vertical bars show standard errors of the mean.**

#### *Between Group Differences*

Efficiency scores for Group A and Group B were compared using an independent t-test and no significant difference was found between the groups at both the second ( $t(9) = 0.195$ ,  $p = 0.850$ ) and third ( $t(9) = 0.420$ ,  $p = 0.684$ ) assessment points. Analysis of variance between groups was performed, and there was no significant difference between groups at the first [ $F(1, 9) = 0.000$ ,  $p = 0.998$ ], second [ $F(1, 9) = 0.038$ ,  $p = 0.850$ ] or third [ $F(1, 9) = 0.176$ ,  $p = 0.684$ ] assessment points.

### *Within Group Differences*

There was a significant increase in efficiency scores from assessment one to assessment two for both Group A ( $t(10) = 3.943$ ,  $p = 0.003$ ) and Group B ( $t(8) = 2.606$ ,  $p = 0.031$ ), and from assessment two to assessment three for Group B ( $t(8) = 5.165$ ,  $p = 0.001$ ) and Group A ( $t(10) = 3.528$ ,  $p = 0.005$ ). No significant change in efficiency score was found from assessment one to assessment three for both Group A ( $t(10) = 0.169$ ,  $p = 0.869$ ) and Group B ( $t(8) = 0.536$ ,  $p = 0.606$ ).

## **3.5 Self-Report Measures**

Not all participants fully completed the questionnaire – only two (one from Group A and one from Group B) completed it in its entirety. Unless otherwise specified, the results below are for those sections that all participants did complete. Full transcripts of each participants responses to the items “*please list five negative aspects of the simulator*”, “*please list five positive negative aspects of the simulator*”, “*what prevented or discouraged you from using the patient simulator program?*” and “*please list at least three things that you think might have encouraged you to use the patient simulator program more often/more regularly*” are provided in Appendix IX.

### **3.5.1 Practice Time**

Group A spent a mean of 108 minutes ( $SD = 24.03$ ) and Group B a mean of 129 minutes ( $SD = 51.5$ ) practising with the simulator. An independent t-test was performed and no significant difference was found between the practise times of each group ( $t(9) = 0.917$ ,  $p = 0.383$ ).



### 3.5.2 Cases Attempted

Group A attempted a mean of 17 cases (SD = 9.26) and Group B attempted a mean of 17.4 cases (SD = 8.38). An independent t-test was performed and no significant difference was found between the number of cases attempted by each group ( $t(9) = 0.043$ ,  $p = 0.966$ ). One participant in Group B attempted two cases more than once, and all other participants tried each case once only.

### 3.5.3 Positive and Negative aspects of the software

Participants were asked to identify five negative aspects of the simulator. The primary complaint was that they were unable to get answers to all questions from the avatar (N = 5), and that the program crashed or froze during use (N = 5). Further, one participant reported that *“you can’t ask questions in a way you would naturally word them – you can get away with keywords only so you don’t have to ask full questions”*, and other participants (N = 2) expressed similar concerns. Four participants identified a lack of feedback from the program as a negative aspect, and a further four reported difficulties with finding the appropriate keyword to ask the virtual patient specific information. The patient did not always understand the user’s questions (N = 2) or would answer inappropriately (N = 4), and the cases were not detailed enough in some areas when the user wanted to ask follow-up questions (N = 4). There were limits on the realism of the virtual patient (N = 2) – *“the avatar looks funny”*, and one participant thought that the inability to see which questions they had already asked limited their learning. Not all participants fully completed this section of the questionnaire.

When asked to identify positive aspects of the simulator, seven participants reported that *“it is good for going over general areas to cover on case history”* and

that it *“helps with memorisation”*. Participants also reported that it was a useful tool to practise differential diagnosis and management (N = 4), was easy to use (N = 4) and quick to respond (N = 4). The PSP was considered relevant (N = 1), interesting to look at (N = 1), a safe way to practise at one’s own pace (N = 2), a flexible way to learn (N = 2), and a fun way to practise (N = 3). Two participants saw the ability to have numerous possible clients as a strength of the program, and a further two thought that the voice audio made the patient seem more realistic. Not all participants fully completed this section of the questionnaire.

#### **3.5.4 Factors Affecting Simulator Usage**

Seven of the eleven participants identified time constraints as the reason they did not use the simulator more during their two week training time. Three participants reported that flaws in the program’s design prevented them from practising more often; with one participant saying *“it’s just a computer, no personal interaction. Really frustrating if the computer doesn’t understand your questions”*. The remaining participant did not complete this part of the questionnaire and thus declined to answer.

When asked *“what might have encouraged you to use the patient simulator program more often/more regularly?”* four participants identified fewer time constraints and having an assessment on the software as motivating factors. Additionally, if the software was able to answer more of the user’s questions (N = 3) and had a greater variety of cases available (N = 2) the participants report that they may have used it more. Further encouraging factors would have been if the software was available on more university computers or students’ home computers (N = 4), and if there was a set time in the course curriculum for everyone to practise with the software (N = 1).

### **3.5.5 Perceived Usefulness**

Group A rated the usefulness of the software as a tool for practising case history taking a mean of 4 (SD = 1.26) on the 7-point Likert scale, and Group B rated a mean of 5.4 (SD = 0.55). A significant difference was found between these ratings when an independent t-test was performed ( $t(9) = 2.287$ ,  $p = 0.048$ ).

### 3.6 Summary of Main Findings

The main findings of this study are summarised as follows:

1. *Accuracy*: No significant difference was found in written scores between groups at any of the three assessment points. A significant difference was found in verbal scores between groups at the second assessment point, but not at the first or third assessment points. Both groups demonstrated significant within group improvements in written and verbal scores from assessment one to assessment three.
2. *Experience*: No significant difference was found between groups at any of the three assessment points.
3. *Confidence*: No significant difference was found between groups at the first and second assessment points. Group B had significantly higher confidence scores than Group A at the third assessment point. Both groups significantly increased in confidence from assessment one to assessment three.
4. *Efficiency*: No significant difference between groups was found at any of the three assessment points. Both groups had a significant increase in efficiency scores from assessment one to assessment two, and a significant decrease in efficiency scores from assessment two to assessment three.
5. *Self-Report Measures*: There was no significant difference in practice times or number of cases attempted between groups for the training periods. Participants identified further adjustments that need to be made to the software including improving realism, allowing the avatar to be able to answer more questions, and the inclusion of feedback. The simulator was perceived to help with memorisation of content, differential diagnosis, was easy to use, and

quick to respond. Time constraints were the main factor preventing participants from using the software more often during the training period, and Group B rated the perceived usefulness of the software as a training tool for taking case histories significantly higher than Group A did.

## 4 Discussion

This study aimed to determine whether or not Master of Audiology students perform better on case history tasks following training on a new patient simulator versus traditional clinical education methods alone (role-play and observation). Software development took part in two phases. Phase One involved the development of audiograms, collection of otoscopic images and generation of a brief summary of case history information for 25 individual cases. Phase Two involved the development of comprehensive case histories for the 25 virtual patients and identification of triggers for eliciting each piece of information from the virtual patient.

Student training with the software involved an alternating treatment design across groups. Twelve first year Master of Audiology students at the University of Canterbury were invited to participate, and took part in a pre-test where they were asked to obtain an audiological case history from a standardised patient. Based on their scores for accuracy, experience, confidence and efficiency, the participants were assigned to one of two groups (Group A and Group B). Group A trained with the PSP over a two week period while Group B continued with traditional training methods, then both groups were again assessed with a standardised patient. It was hypothesised that at this point Group A would score significantly better than Group B in accuracy, confidence and efficiency. Following this, Group B trained with the PSP for a two week period while Group A continued with traditional training methods, then both groups were assessed one final time with a standardised patient. It was hypothesised that at this point both groups would score similarly in accuracy, confidence and efficiency.

A summary of the findings is provided in Sections 4.1 to 4.4 and is discussed in relation to other studies in the field of Audiology and beyond that address virtual reality in education. The strengths and limitations of the current study as well as the clinical implications and directions for future research are also discussed.

## **4.1 Accuracy**

It was hypothesised that Group A would score significantly better at the second assessment point than Group B in both written and verbal accuracy. Additionally, students were expected to show significant improvements in accuracy following training on the software. Greater gains were expected in verbal accuracy than written accuracy scores as the software did not explicitly target written skills.

### **4.1.1 Written Score**

No significant difference was found between groups at the second assessment point. This lack of significant improvement in accuracy following simulation training supplementary to traditional education methods compared with traditional education methods alone is in contrast to the findings of Antonietti et al. (2000). However, participants were not required to record the virtual patient's answers as part of the training package so this measure acted as a control for the verbal accuracy scores. If Group A had scored significantly higher than Group B on written scores as well as verbal scores at the second assessment point then it is possible that some external factor other than simulation training had contributed to this. As this is not the case, the significant difference in verbal scores can more reliably be attributed to simulation

training than any other external factor improving Group A's performance overall and not Group B's.

Both groups showed significant improvement in written scores across all three assessments, reflecting the skills they acquired on clinical placements during this time. While Group B plateaued from assessment two to assessment three, Group A's scores significantly decreased. This may in part be due to the reduced amount of practise time that Group A had when they did not have access to the simulator compared with when they were in the training phase, which meant that their initial improvement in performance was not able to be maintained.

#### **4.1.2 Verbal Score**

Significant within-group change was observed from assessment one to assessment two for both Group A and Group B, with greater gains for Group A.

This significant difference in verbal scores between groups at the second assessment point, combined with the absence of a significant difference between groups at the final assessment point, supports the previous findings of Antonietti et al. (2000), Malone (1981), Sitzmann (2011) and Vogel et al. (2006) that simulation training enhances comprehension, memorisation, and transference of skills to other environments. Both groups benefited from traditional learning methods between the first two assessments, but the addition of simulation training provided extra benefit to Group A. However, no significant change within group change was observed from assessment two to assessment three. In light of this it is possible that the participants received greater benefit from simulation training earlier in the academic year as demonstrated by the significant gains for Group A following training – a result not replicated by Group B. While the improvement observed between assessment two and



assessment three for Group B was not statistically significant, a greater difference may have been observed with a larger group size – the findings of this investigation are limited somewhat by their statistical power.

## **4.2 Experience**

It was hypothesised that there would be no significant difference in experience scores between groups at all assessment points, and the findings from this study support this. While the *type* of clinical experiences each participant had throughout the duration of the study was not controlled for, these results confirm that neither group had a significant advantage in terms of *quantity* of clinical experience during both the software training and traditional education methods only conditions. Although Group A's mean experience score significantly increased from the first assessment to the second, Group B's experience scores were still not significantly different, which means that any between-group differences observed in the other three measures can more reliably be attributed to simulator usage than external clinical experience.

## **4.3 Confidence and Efficiency**

While the literature (The Physiotherapy Consortium, 2010) supported the hypothesis that there would be a significant difference in confidence and efficiency scores between groups after using the simulator, this was not the case for this study.

#### **4.3.1 Confidence**

No significant difference in confidence scores between groups was observed at assessment two, contrary to the findings of Sitzmann (2011) and Randell, Hall, Bizo, & Remington (2007) who report increased confidence and self-efficacy following simulator training. However, Group B reported significantly higher confidence than Group A at the third assessment point. Blood, Mamett, Gordon, & Blood (2010) surveyed 599 practising Speech and Language Pathologists to determine their clinical confidence levels and predictors of confidence, amongst other things. Confidence is related to knowledge, perceptions, and behaviour, and Blood et al. identified that a key predictor of confidence is the ability to obtain knowledge and experience. Thus, in this present study, both Group A and Group B increased in confidence from assessment one to assessment three as they increased their knowledge base through course materials and were exposed to a variety of clinical experiences through the simulator software and clinical placements. The lack of difference between groups in confidence scores at the second assessment point could perhaps be attributed to a lack of familiarity with the assessment task. Both Groups would have been more familiar with the task by the third assessment.

Given that the literature has shown increased confidence following simulator use and the longer time between assessments one and two than assessments two and three, the cumulative effects of familiarity with the task and simulator training likely resulted in the significantly higher confidence scores obtained by Group B at the third assessment point. Similarly, less familiarity with the assessment task at the second assessment point may have counteracted the confidence benefits of simulator training for Group A, thus resulting in no significant difference between groups.

Alternatively, the increases in confidence observed may simply be due to the practice effect – when a participant becomes progressively better or progressively worse at performing a task over time. While Group B improved in confidence from assessment one through to assessment three, Group A lost confidence following assessment two. It is possible that Group A reported feeling less confident at assessment three than assessment two as they had not had recent simulation practice and they recalled feeling more confident at assessment two.

Either way, it appears that simulator use has had some positive impact on confidence scores even though the between-group differences were not as expected.

#### **4.3.2 Efficiency**

No significant difference in efficiency scores between groups was observed at any of the three assessment points, contrary to the hypothesis supported by the literature (The Physiotherapy Consortium, 2010). According to Kuhlthau (1991) an increase in confidence corresponds to an increase in clarity and focus in thoughts, which should equate to improved efficiency. This was not the case, and simulator use appears to have had no effect on the participant's efficiency score. This may be due to problems with the program itself, as described by the participants. They reported that the avatar did not always respond to their questions or often did not understand, and that they had difficulty finding ways to phrase their questions that the avatar would understand, which meant that the students were unable to practise efficient questioning on the software. In light of this, improvement in this skill cannot be expected.

Of particular note is the significant increase in efficiency scores (which equate to less efficient) from assessment one to assessment two for all participants, and the

significant decrease from assessment two to assessment three. This result is explained by the Personal Construct Theory, which describes the process of constructing meaning from the information one encounters (Kuhlthau, 1991). New information is gathered and interpreted in a series of phases, and confusion mounts as inconsistencies and incompatibilities are identified when compared with the learner's existing knowledge. This phase accounts for the increase in efficiency scores as the participants are likely questioning and redeveloping the constructs they held. Once the existing knowledge is combined with the new information and new constructs emerge, the learner moves forward and thus the efficiency scores decreased again. Following this theory, efficiency scores are expected to further improve (decrease) over time as the participants continue to refine their history taking abilities.

#### **4.4 Self-Report Measures**

Comparison of mean practise times and number of cases attempted between groups was conducted to control for the influence of these variables on the four measures described above. As there was no significant difference between groups for either variable, any differences observed on the measures could more reliably be attributed to use of the simulator rather than traditional learning methods. Additionally, any similarities between groups at assessment points where differences were hypothesised to occur cannot be attributed to the frequency and manner in which participants used the software. One participant in Group B did comment *“if I had been in the first group I would have had more time to allocate to practice”* (see Appendix IX), but the comparison of mean practise times between groups proves that this was not the case overall.

Group B rated the simulator as significantly more useful as a tool for practising taking case histories than Group A did, which is perhaps due to the timing of the inclusion of training into the course. This is contrary to the verbal score findings that indicated that participants may receive greater benefit from simulation training earlier in the academic year. While Group A demonstrated significant gains in verbal accuracy following simulation training Group B did not, yet Group B rated the simulator as more useful. However, Group B reported significantly greater gains in confidence than Group A, which suggests that attitudes towards the simulator affect confidence more than performance. While performance gains were greater earlier in the academic year when the case history format was less familiar to the participants, perception of the software was more positive later in the academic year when the tasks were more familiar and likely easier. Students are more likely to do something if they feel they are successful at it (Dickinson, 1995), and this increased motivation increases the possibility of success and the ability to generalise the skills learnt to other environments (Malone, 1981). Taking this into account, the timing of simulation training in the second semester should be considered if the software is to be used with Audiology students in the future. Earlier inclusion will likely give greater performance gains, but later inclusion will likely enhance self-efficacy – consistent with the findings of Randell, Hall, Bizo, & Remington (2007).

It is also possible that the participants in Group A helped those in Group B by recommending ways to work around the problems in the software. If this was the case, then it seems likely that students will benefit more from simulator use if their peers are able to help them troubleshoot any difficulties that they encounter.

#### **4.5 Limitations and Directions for Future Research**

It is important to acknowledge the limitations in the methodology of this study when considering the results described above. Of primary relevance is the small sample size used in this study. There were only eleven participants, all of whom attended the same university, so the ability to generalise these findings to the population of Audiology students as a whole is limited. Originally students from another University in New Zealand were going to take part in this study as well, but due to changes in University timetabling following the Canterbury earthquakes<sup>2</sup> it became no longer feasible as the two educational programmes were no longer operating in synchrony.

Further complications arose from the earthquakes as University term dates were shifted and compressed, resulting in an increased academic and clinical workload for participants. This meant that all participants were extremely busy with other coursework, which may have contributed to some participants failing to complete the required two hours of training and/or others only completing their two hours the day before the assessment session. However, this may also have been simply due to a lack of interest in the task, personality traits, or learning styles. In order to compensate it may have been prudent to provide the participants with set times at which they should train with the software, which would take place throughout the training phase at regular intervals.

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<sup>2</sup> The Canterbury region experienced a shallow, magnitude 6.3 earthquake on February 22<sup>nd</sup> 2011 that caused widespread damage to Christchurch City and closed the University of Canterbury. The Department of Communication Disorders (which houses the Master of Audiology Programme) remained closed until May 1<sup>st</sup> 2011, delaying the start of the academic year by two months. A further magnitude 6.3 earthquake struck on June 13<sup>th</sup> 2011, closing the University again. There were additional University closures and evacuations throughout the year as further large aftershocks required buildings to be checked before they could be re-entered.

The earthquakes affected the participants in other ways as well. The range of clinical experiences participants came across on external placements was limited as several clinics used regularly for placements were closed or damaged, and there was a disproportionately high patient DNA (did not attend) rate following each large aftershock across all clinics. This may have biased for greater gains with simulator use than traditional methods alone, and thus it is difficult to generalise the results of this study to the wider population. Additionally, the impact of the emotional and physiological stress of the earthquakes on these participants was not evaluated, and this stress may have affected their academic performance and ability to learn.

Ceyhan & Ceyhan (2007) researched the quality of life and academic achievements of earthquake survivors following the 7.4 and 7.2 magnitude earthquakes on 17 August and 12 November respectively in Marmara, Turkey in 1999. 407 student volunteers took part in the study, 201 of whom had experienced either or both earthquakes. Quality of Life was measured using the World Health Organisation Quality of Life Instrument-100 (WHOQOL-100), and it was found that scores in the psychological and environmental domains were significantly less for those who had experienced the earthquakes, even six years after the events. The psychological domain (PD) includes negative feelings, positive feelings, thinking, learning, memory, and concentration, while the environmental domain (ED) includes financial resources, and opportunities for acquiring new information and skills among other things. It was also found that the levels of academic achievement of the earthquake survivors were significantly lower than of those not exposed to earthquakes, and it was postulated that individuals may develop attention deficit and memory problems after a traumatic event. In light of these findings it is reasonable to assume that the Audiology students likely would have scored higher overall had the

earthquakes not occurred during their academic year. Their performance is likely to have been affected by impaired concentration and memory deficits, and if this had not been the case it is possible that the participants may have achieved greater gains from simulator use.

Every effort was made by the University and the participants to continue as best they could with their education and, short of running this study again with a larger sample size and no natural disasters, nothing further could have been done to control for these limitations. Students are always going to be busy, so even without earthquakes they may still find that time-pressure prevents them from using the simulator to its full potential. A clear strength of the validity of this study's results is the well-matched participant groups, even while excluding the data from the twelfth participant who failed to follow the instructions. Both groups reported similar experience scores at each assessment point, so while their overall clinical experience may not have been as varied as that of other year groups this does not lessen the validity of the increased verbal scores shown following simulator use.

A further limitation of this study is that the participants only had access to the software for training over a period of two weeks and, as such, the long-term effects of simulator use were not evaluated. Thus although these results have shown short-term benefits, further research is needed with longer training and follow-up periods to evaluate any long-term improvements in student performance. It is also worth noting that learning effects may be greater if the training period was able to be prolonged. It is promising, however, to observe significant improvements in verbal scores with only a short training time. While only two hours of training was minimal (and some participants did not even achieve this), this was unavoidable as it was imperative that



participation in this study did not negatively impact on the participants' coursework in any way given the already increased pressure on the students.

The one participant whose results were excluded from the study presents an interesting question – did they not understand how to use the software because of a lack of adequate instruction or because the software itself is too complicated? Other participants reported initial confusion regarding simulator operation despite the clear instructions provided, but this is likely due to the delay in receiving the instructions and beginning training. As such, the PSP would likely benefit from the inclusion of a manual into the program's interface, and a tutorial on simulator use should become mandatory rather than optional prior to commencement of training.

There are some distinct improvements to be made to the program design – many participants reported that they were unable to easily access the software as often as they desired because it was only available on certain computers. This was a direct result of software development still being in the initial phase – changes were made to the software right up until the first group began training. Sitzmann (2011) reports that simulation games only reach their full potential if users can access them as many times as desired, and it is for this reason that a web-based simulator is preferable to the current method of delivery. Web-based programs are extensible and scalable, system performance can be easily monitored and adjusted accordingly (Zary, Johnson, Boberg, & Fors, 2006), and this may have encouraged the participants to spend more time training with the software. Indeed, four participants stated that having the software available on their home computers would have encouraged them to use it more. Further, Huwendiek et al. (2009) found that students prefer simulation programs that provide feedback on accuracy to the user, and this is one component that is clearly missing from the software design at this stage. Further development of

the software needs to take place that includes feedback for the user, as per the recommendations of Issenberg et al. (2005), Lieberth & Martin (2005), and Dickerson et al. (2005) for successful simulation training.

It is also worth recognising that the assessment sessions only evaluated the participants' knowledge of content and any perceived changes in their confidence rather than their interpersonal skills in interviewing patients. Dyche (2007) reports that viewing clinician-patient interaction as clinician dominated fails to recognise the reciprocal nature of the interaction, the importance of being able to adapt communication to individual patients, and the skill involved in interpreting patient cues. While the PSP does not specifically target the development of these skills, further research may demonstrate an effect. There is little in the current literature regarding the acquisition of nonverbal communication skills from a simulation training program that does not explicitly target or require these skills. Dickerson et al., (2005) are developing an immersive VR assessment tool for medical students that, in the future, is hoped to be able to assist in the evaluation of these interpersonal skills. However, this is a new area of research and one to be explored.

Finally, there are some limitations to the self-report questionnaire given to the participants at the completion of their training period. Not all participants answered every question, which may have biased the results. Further, participants may have interpreted the questions differently to how they were intended, or may not have answered honestly. To attempt to compensate for this, the questions were worded as simply and specifically as possible to minimise confusion. Participants were specifically encouraged to answer the questionnaire as honestly as possible when it was given to them and were informed that their responses would be kept anonymous to everyone except the primary examiner.

Further considerations for future research and software development include the addition of voice recognition to enhance the realism of the program, as with *Conversim* (Harless, Zier, Harless, & Duncan, 2003). It is worth investigating whether or not this would further increase students' learning outcomes. Similarly, there may be differences in learning and performance if the virtual patient responds to the user's questions with video clips of a real person rather than just audio and text, as Huwendiek et al. (2009) report that the use of video is thought to increase authenticity. Enhanced VR authenticity is associated with learning success (Grunwald & Corsbie-Massay, 2006).

#### **4.6 Clinical Implications**

This study presents objective evidence showing the positive effect of training with a new, rudimentary virtual audiometry package on student performance in verbal accuracy and confidence on case history taking tasks. While no effect was observed on written accuracy or efficiency, these initial findings provide a basis for future, more comprehensive, research into this area. Participants reported that the PSP is a useful tool for practising taking case histories and nine of the eleven participants thought that mandatory use of the PSP should be incorporated into the clinical audiology course in the future once the case history component of the program is fully integrated with audiometric and immittance measures. Simulation is not an adequate substitute for interaction with real patients (Theodoros, Davidson, Hill, & MacBean, 2010), but the results of this study show that it has potential as a supplement to the existing course structure. A proposed model for inclusion of the software into the

current Audiology curriculum (once the software itself is developed further following the recommendations above) is displayed in Figure 8.

Current course structure	Proposed inclusion
<p>Students learn the skills (in class)</p> <p>↓</p> <p>Peer role play &amp; practice (tutorials)</p> <p>↓</p> <p>Practice with real patients</p> <p>↓</p> <p>Achieve NZAS requirements for graduation</p>	<p>Students learn the skills (in class)</p> <p>↓</p> <p>Peer role play &amp; practice (tutorials)</p> <p>↓</p> <p>Practice with PSP</p> <p>↓</p> <p>Practice with real patients</p> <p>↓</p> <p>Achieve NZAS requirements for graduation</p>

**Figure 8. Proposed Inclusion of the Patient Simulator Program (PSP) into the Current Master of Audiology Course Structure - Based on a model by The Physiotherapy Consortium (2010)**

## **4.7 Conclusion**

While there is some report in the literature of the use of virtual reality in clinical audiology, there is little objective data regarding the effectiveness of this approach as a training tool. This was a pilot study to measure the effects of a new patient simulator program on student performance in case history tasks. Despite the small sample size, a small positive effect on verbal accuracy and confidence measures following training with the simulator was observed. Although several problems with the software design were identified, once these are fixed even greater gains are expected. Additionally, students had positive reactions to the software and see a potential place for its use in the current Master of Audiology training programme. As such, investment into further development of the software is warranted with the ultimate goal of using it to supplement clinical experiences for Audiology students.

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# **|Appendices**

## **|Appendix I**

Human Ethics Committee approval letter, participant information sheet and participant consent form

HUMAN ETHICS COMMITTEE

Secretary, Lynda Griffioen  
Email: [human-ethics@canterbury.ac.nz](mailto:human-ethics@canterbury.ac.nz)

Ref: HEC 2011/27/LR

24 June 2011

Sarah Howland, Libby Sanderson & Alexandre Heitz  
Department of Communication Disorders & HIT Lab NZ  
UNIVERSITY OF CANTERBURY

Dear Sarah, Libby and Alexandre

Thank you for forwarding to the Human Ethics Committee a copy of the low risk application you have recently made for your research proposal "Interactions with virtual patients in clinical simulation".

I am pleased to advise that this application has been reviewed and I confirm support of the Department's approval for this project.

With best wishes for your project.

Yours sincerely



Michael Grimshaw  
**Chair**  
***University of Canterbury Human Ethics Committee***

## Participant Information

*You are invited to take part in a study being conducted by researchers from the Department of Communication Disorders and the Human Interface Technology Laboratory (HIT Lab) at the University of Canterbury. This project aims to develop a virtual client simulator program to be used to supplement traditional methods of teaching clinical skills in audiology programmes.*

**The aim of this study** is to find out if using a virtual client simulator in addition to the current clinical audiology course's traditional teachings could help you to refine your skills further when interacting with real patients.

### **Who are the researchers?**

A team of researchers from the Department of Communication Disorders and the HIT Lab are conducting this study. The researchers from the Department of Communication Disorders are Elizabeth (Libby) Sanderson, Sarah Howland, Jonny Grady and Dr Catherine Moran. The HIT Lab researchers are Alexandre Heitz and Dr Andreas Duenser. This study forms part of Alexandre Heitz's PhD and Libby Sanderson and Sarah Howland's Masters degree.

### **How were participants selected?**

First year students in the clinical audiology course have been invited to take part as they are the target audience for the virtual client simulator.

### **What will the research involve?**

We are asking you to practice seeing clients using the virtual simulator, in addition to your regular coursework, for a block period of three weeks and to take part in three assessment activities over the next six weeks.

### **What are the benefits of this study?**

This study will allow you to further practice your skills in clinical audiology before working with real clients, as well as providing you with additional training opportunities.

It will also provide information that will help in developing more realistic virtual clients and to help refine our simulator before further use in the clinical audiology course.



### **Do I have to take part?**

No, your participation is entirely voluntary (your choice). If you choose not to take part this will not affect your academic progress in any way. We hope that you will participate as your results will provide us with valuable information for refining the virtual client simulator further. You may withdraw from the study at any time. However, taking part in all activities and tasks will provide the best information for the study.

### **Will my personal details be kept confidential?**

Yes. Your anonymity will be maintained by using aliases. Access to the data collected is limited solely to the researchers named above. The data will be stored securely at the University of Canterbury for five years following completion of the project, at which time the data will be destroyed.

### **What happens to the results of the study?**

The results of this study will allow us to refine the virtual client simulator. Results will be reported as part of the project in journal publications, conference presentations, and on the internet. Results will also be reported as part of Alexandre Heitz's PhD thesis, and Libby Sanderson and Sarah Howland's Masters theses.

If you would like a copy of the results of this study, please contact Alexandre Heitz, Libby Sanderson or Sarah Howland.

### **Who has approved this study?**

This study has been reviewed and approved by the Human Interface Technology Laboratory (HIT Lab NZ), and the University of Canterbury Department of Communication Disorders. It has also been reviewed and approved as part of the University of Canterbury Human Ethics Committee low risk process.

**Please Contact Alexandre Heitz, Libby Sanderson, Sarah Howland, Andreas Duenser or Catherine Moran if you have further questions.**

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## Participant Consent Form

I have read and understand the participant information sheet for this study.

I understand that I will be required to practice using the Virtual Patient Software over a period of three weeks in my own time in addition to my regular coursework. I also understand that I will be required to take part in three separate assessments, each lasting approximately 30 minutes, at three week intervals over the course of the study (6 weeks total).

I understand that my participation in this study is voluntary and that I may withdraw at any time without penalty.

I understand that any information or opinions I provide will be kept confidential to the researchers (Sarah Howland, Libby Sanderson, Alex Heitz and their supervisors – as listed on the participant information sheet) and that my identity will not be revealed in any published or reported data. I also understand that all data will be recorded using aliases.

I understand that all data collected in this study will be kept secure in a locked and secure facility at the University of Canterbury for a minimum of five years before being destroyed.

I understand that the assessments involved as part of this study are in no way related to determining my grades for any of my university courses.

I am aware that I may request from the researchers a personal copy of my results and/or performance on assessment tasks following completion of the study.

I understand that I may contact Sarah Howland, Libby Sanderson, Alex Heitz or their supervisors if I require further information. I may also contact the Chair, University of Canterbury Human Ethics Committee if I have any complaints.

Name \_\_\_\_\_

Signature \_\_\_\_\_ Date \_\_\_\_/\_\_\_\_/\_\_\_\_

## **|Appendix II**

### Case History Summaries for Phase One

1. *Normal hearing L&R*
  - 49 year old office worker, came into clinic for free hearing check
  - Feels hearing in both ears is similar
  - Reports some difficulty hearing conversation in noisy restaurants/bars but has no other concerns
  - No history of tinnitus or vertigo
  - Good general health
  - Uses the telephone in his left ear
  - Had tympanostomy tubes as a child
2. Bilateral *presbycusis* (moderately sloping loss)
  - 83 year old, brought into clinic by daughter who was concerned about her parent's deterioration in hearing over the last few years
  - Feels right ear may be slightly better than left
  - Reports feeling "left out" of the conversation at large family gatherings sometimes, and has had to turn the radio and television up a bit recently
  - Does not experience tinnitus, but sometimes get dizzy for a few seconds when she stands up too fast
  - No history of noise exposure
  - Had hip replacement ten years ago, and has mild hypertension.
3. Bilateral *idiopathic sensorineural h/loss* (mid-frequency dip/cookie-bite configuration)
  - 35 year old, referred by GP for concerns regarding ability to hear coworkers
  - Difficulty hearing on the phone, and complains that people seem to "mumble". Reports significant difficulty hearing in group situations
  - No family history of hearing loss
  - No tinnitus or vertigo, no history of noise exposure
  - Good general health
4. Bilateral *Noise Induced h/loss* (standard 4kHz 'notched' h/loss)
  - 53 year old factory worker, came into clinic for free hearing check
  - Has not worn hearing protection at work until last few years – worked in the same factory for thirty years
  - Has noticed that other people's speech does not seem as clear as it used to
  - Feels hearing is similar in both ears
  - No family history of hearing loss
  - Hears a high-pitched ringing in both ears, but this is not bothersome
  - Good general health
5. Bilateral *presbycusis* (flat moderate loss) with BPPV (no extra hearing loss)
  - 69 year old retired schoolteacher, referred by GP to clinic as is sometimes having difficulty understanding what people are saying, particularly in the presence of background noise. GP is also concerned about episodes of dizziness patient is experiencing
  - Is also struggling to hear the radio in the car, and has turned the television up at home
  - Feels hearing is similar in both ears
  - Both parents had significant hearing losses by their 80s
  - Reports occasional brief periods of rotary vertigo (5-20 seconds) after rolling over in bed or while gardening

- No history of noise exposure
  - Good general health
6. Bilateral sensorineural h/loss with high frequency *cochlear dead regions*
- 67 year old brought into clinic by spouse who complains they frequently have to repeat what they say
  - Patient reports difficulty understanding what people say, and refuses to use the telephone as they cannot hear
  - Plays the piano and complains that highest notes on the keyboard are distorted and “hiss”, but noone else seems to hear this
  - Feels hearing is slightly better in left ear
  - Hears high-pitched ringing sounds in both ears which impairs their ability to get to sleep at night
  - Has not seen an ENT at any time
  - No history of noise exposure
  - Experiences angina
7. L *Meniere’s disease* (rising configuration), with R *normal hearing*
- 50 year old, referred by GP for fluctuating hearing loss, tinnitus and vertigo
  - Patient reports episodic hearing loss in their left ear, accompanied by a feeling of pressure. Right ear feels normal, and they have not noticed any hearing loss in this ear
  - Describes tinnitus as a “low, roaring sound”
  - No history of noise exposure
  - Good general health, apart from episodes of vertigo
8. R *labyrinthitis* (moderately severe, flat), with L mild sloping *presbycusis*
- 67 year old, referred by GP for sudden decrease in hearing in right ear and episodes of vertigo
  - Had “attack” two months ago where the room started spinning and they heard a loud buzzing sound in the right ear. Has recurrent attacks of varying severity, but cannot establish a cause. Reports a blocked feeling in the right ear during the attacks
  - Prior to onset of these symptoms, the patient had noticed some difficulty hearing conversation in background noise but this has worsened significantly since
  - Good general health otherwise
9. L *sudden sensorineural h/loss* (profound loss) and R *noise induced h/loss* (notched loss)
- 47 year old mechanic, referred by GP for sudden drop in hearing
  - History of occupational noise exposure
  - Woke up two days ago and could barely hear out of right ear
  - No family history of hearing loss
  - Chronic asthma
10. L *Bell’s palsy* (severe/profound) on top of bilateral *presbycusis* (mild/moderate sloping)
- 77 year old, referred by GP for left ear pain and high sensitivity to loud sounds
  - Patient reports difficulty with localising sounds, and feels that hearing is better in the right ear

- Significant difficulty hearing in background noise, and moderate difficulties understanding conversation one to one
  - No tinnitus or vertigo, but feels that left side of face is “weaker” than right
  - No history of stroke or head injury
11. R *meningitis* (sensorineural, profound mid-high frequency) and overlay of *ototoxicity induced* sensorineural loss bilaterally (mild high frequency)
- 35 year old patient who reports significant hearing loss in right ear since childhood
  - Needs to see the face of the person they’re talking to in order to understand what they’re saying, but has noticed that over the past three years this has become more and more difficult. Concerned that hearing in left ear may have deteriorated
  - No family history of hearing loss
  - Had meningitis as a baby, and is currently in remission from lymphoma – which was treated with cisplatin
12. R *acoustic neuroma* (normal low freq steeply sloping to profound high freqs) with L *normal hearing*
- 54 year old patient referred by GP for progressive hearing loss in right ear
  - Reports difficulty hearing on the telephone, and persistent tinnitus in right ear
  - Patient has no concerns about left ear
  - No vertigo, but reports that right ear feels “blocked”
  - No history of noise exposure, and no significant medical history
13. Bilateral *CMV* with different sensorineural hearing configurations in each ear; L worst.
- 16 year old brought into clinic by new foster parent who is concerned about the volume of the television and radio at home – the patient frequently complains they cannot understand what is being said even with the volume raised
  - Struggling academically. Patient says they don’t like school, and that their teachers all mumble
  - Foster parent reports that the patient will often turn their right ear towards the sound source in an apparent attempt to hear better
  - Has been in multiple foster homes, and has not had a hearing test before
14. Bilateral asymmetrical *noise induced h/loss*, with L moderate-severe 4-6kHz ‘notch’ and R mild 4-6kHz notch, due to firearms work
- 55 year old farmer, right-handed
  - Experiencing difficulty hearing on the phone, in meetings and at church
  - Feels left ear is worse than the right – hears a buzzing sound in left ear
  - Does a lot of shooting on the farm
  - No significant medical history
15. L *endolymphatic hydrops* (moderately-severe rising to mild, then sloping to moderate) with R *otitis externa* (normal hearing)
- 70 year old retired nurse, experiencing fluctuating hearing loss in the left ear and pain in the right ear
  - Reports tinnitus in the left ear and episodic dizzy spells
  - Pain in right ear has been worsening over the last two weeks, but hearing seems unaffected

- Has not yet visited GP or ENT
  - Recently has had difficulty understanding what people are saying, particularly in the presence of background noise
16. R *retracted tympanic membrane* (15-25dB rising low freq conductive component) with symmetrical border-line *normal hearing* in both ears.
- 27 year old, came into clinic for free hearing check
  - Reports no difficulties with hearing, but feels that right ear has been slightly blocked for the past month or so
  - No family history of hearing loss
  - No tinnitus or vertigo
  - No significant medical history
17. R *otitis media with effusion* (flat 40-50dB loss; normal BC) and L *normal hearing*
- 18 year old referred by GP
  - History of middle ear infections
  - Feels right ear is significantly worse than left ear. Cannot localise sound
  - Family history of hearing loss – cousin has a cochlear implant
  - No significant medical history
18. L *tympanosclerosis* (15-20dB low-to-mid freq conductive component) and bilateral *presbycusis* (moderate to profound sloping ; ‘off the chart’ at 6 & 8 kHz)
- 85 year old referred to clinic by GP for white chalky substance on left eardrum and extreme difficulty hearing in background noise and on the telephone
  - History of otitis media
  - Has become socially withdrawn due to difficulties understanding speech, even one on one
  - Reports ringing in both ears
  - No balance difficulties or other significant health problems
19. R *perforated tympanic membrane* (20-30 dB conductive component) and bilateral *idiopathic sensorineural hearing loss* (mild, low-to-mid freq h/loss, sloping to moderately severe in the high freq)
- 47 year old, came into clinic complaining of recent pain in and discharge from the right ear with associated hearing loss
  - Feels they have always had some difficulty hearing high-pitched noises, and often miss the telephone ringing
  - No tinnitus or balance difficulties
  - No history of noise exposure, or family history of hearing loss
  - Good general health
20. L *wax occlusion* (flat 30dB conductive component) and bilateral *presbycusis* (mild to moderately-severe precipitous h/loss)
- 74 year old retired doctor, came into clinic for free hearing check
  - Reports difficulty hearing grandchildren, and finds they cannot understand family members at gatherings of more than four people
  - Uses telephone on right ear
  - Reports high pitched ringing in both ears
  - Good general health

21. R *ossicular discontinuity* (flat 50-60dB conductive component; normal BC) and L *normal hearing*
  - 24 year old, referred by GP for sudden drop in hearing in right ear following a bar fight last weekend
  - No previous history of hearing loss, tinnitus or vertigo
  - Has not seen an ENT following change in hearing
  - Had meningitis as a baby
22. L *otosclerosis* (30-40dB rising conductive component with Carhart's notch and mild-moderate sensorineural component) and R *idiopathic sensorineural h/loss* (mild rising to normal)
  - 40 year old mother of two, came into clinic for free hearing check
  - Has noticed a gradual drop in hearing in the left ear since the birth of her first child ten years ago
  - Reports difficulty hearing her children whisper – her husband is able to hear them fine
  - Occasionally hears a “hissing sound” in the left ear
  - Mother's hearing progressively deteriorated from her 30s onwards
23. R *cholesteatoma* (40-50dB rising conductive component with mild mid-to-high freq sensorineural component) and L *normal hearing*
  - 50 year old, came into clinic for free hearing check
  - Reports hearing loss in the right ear, and difficulty communicating in groups
  - Right ear is sometimes sore, and on two occasions the pain has been accompanied by dizziness
  - No history of noise exposure
  - Has diabetes and high blood pressure
24. L *aural Atresia* (60-70dB conductive component) with bilateral *idiopathic sensorineural h/loss* (mild mid freq dip/cookie-bite configuration)
  - 32 year old, came into clinic to get custom ipod earphones made as they find that the standard ones constantly fall out of their left ear. Spouse suggested additional hearing test because the patient constantly asks them to repeat themselves
  - Reports significant difficulty with localising sound, and has to ask friends and family to stand on the patient's right hand side in order to hear them
  - No tinnitus or vertigo
  - No history of noise exposure or family history of hearing loss
25. L *bullous myringitis* (15-25dB sloping conductive component) with bilateral *presbycusis* (moderate to severe sloping)
  - 81 year old, brought into clinic by son who is concerned about his parent progressively becoming more and more socially isolated
  - Patient reports pain in left ear for last two weeks – son expressed surprise as he did not know. Has not seen GP about the pain
  - Difficulty understanding friends and family. Does not like noisy environments as they “cannot hear anything”
  - Has not experienced vertigo or tinnitus
  - Had an oral cancer surgically removed 15 months ago



## **|Appendix III**

### Comprehensive Lists of Patient Characteristics for Phase Two

## 1. Normal Hearing L & R

- *49 year old male*

1. I'm here today for a free hearing check
2. I feel my hearing is fine, I'm not really concerned at all
3. I work in an office doing admin
4. I have no family history of hearing loss
5. I feel my hearing is the same in both ears
6. I have some difficulty with hearing conversation in noisy restaurants
7. I'm fine using the telephone
8. I have no problem hearing the television or radio
9. I use my left ear on the telephone
10. I can hear fine in one on one situations
11. I haven't had my hearing tested before
12. I've never experienced tinnitus
13. I've never had any balance problems
14. My face has never felt tingly, numb or weak
15. My ears don't feel full or like there's pressure in there
16. I have never had an operation on my nose or throat
17. I've never had any problems with my tonsils or adenoids
18. I used to get a lot of ear infections when I was a child, but I don't anymore
19. I had grommets when I was a child
20. I have never worked in noisy environments and I don't have any really loud hobbies
21. My general health is pretty good
22. I don't have diabetes
23. I haven't had any major operations
24. I have had no major illnesses
25. I don't have any heart or blood pressure problems
26. I have never had mumps
27. I have never had meningitis
28. I don't take any medications
29. I have never had a head injury
30. I have never had measles

## 2. Bilateral presbycusis (moderately sloping loss)

- *83 year old female*

1. I've come to see you because my daughter is concerned about my hearing
2. I feel my hearing is slightly better in my right ear than my left
3. I have never worked outside the home
4. My father was very hard of hearing, but this only happened as he got older
5. I often feel left out of conversations because I can't understand anyone
6. I can use the telephone fine as long as the volume is turned right up
7. I use my right ear on the telephone
8. I've had to turn the tv and radio up a bit recently
9. Mostly I can hear fine when I'm talking to someone in quiet, as long as they don't speak too quickly
10. I don't like having conversations in noisy environments because it's too hard to hear
11. I haven't had my hearing tested before
12. I never hear any strange sounds in either of my ears
13. Sometimes I get dizzy for a few seconds when I stand up too fast
14. My face has never felt tingly, numb or weak My ears don't feel full or like there's pressure in there
15. I have never had an operation on my ears, nose or throat
16. I have never been to see an ear specialist
17. I've never had any problems with my tonsils or adenoids

18. I don't remember ever getting ear infections
19. I have never worked in noisy environments and I don't have any really loud hobbies
20. My general health is pretty good
21. I don't have diabetes
22. I had a hip replacement ten years ago, but that's my only surgery
23. I have had no major illnesses
24. I have mild hypertension
25. I have never had mumps
26. I have never had meningitis
27. I am taking medication for my hypertension
28. I have never had a head injury
29. I have never had measles
30. I have always experienced that feeling
31. I first noticed my hearing getting worse ten years or so ago

### 3. Bilateral idiopathic sensorineural hearing loss (mid-frequency dip/cookie-bite configuration)

- *35 year old male*
1. I've come to the clinic because I can't hear my coworkers
  2. I feel my hearing is the same in both ears
  3. I work in a school as a teacher aide
  4. I have no family history of hearing loss
  5. I have particular difficulty with hearing on the telephone
  6. I feel like everybody seems to mumble
  7. Sometimes it's hard to hear on the telephone
  8. I use my left ear on the telephone
  9. My wife complains I have the television and radio up too loud but I can't hear them at the level she likes
  10. I can hear fine in one on one situations
  11. I have significant difficulty hearing people in group situations
  12. I haven't had my hearing tested before
  13. I never hear any strange sounds in either of my ears
  14. I've never had any balance problems
  15. My face has never felt tingly, numb or weak
  16. My ears don't feel full or like there's pressure in there, although sometimes when I'm traveling they feel funny when the plane comes in to land
  17. I have never had an operation on my ears, nose or throat
  18. I have never been to see an ear specialist
  19. I've never had any problems with my tonsils or adenoids
  20. I don't remember ever getting ear infections
  21. I have never worked in noisy environments and I don't have any really loud hobbies
  22. My general health is pretty good
  23. I don't have diabetes
  24. I haven't had any major operations
  25. I have had no major illnesses
  26. I don't have any heart or blood pressure problems
  27. I have never had mumps
  28. I have never had meningitis
  29. I don't take any medications
  30. I have never had a head injury
  31. I have never had measles
  32. My hearing has been bad for the past year or so

4. Bilateral noise induced hearing loss (standard 4kHz ‘notched’ hearing loss)

- *53 year old male*

1. I'm here today for a free hearing check
2. I feel my hearing is the same in both ears
3. I work in a factory with loud machines
4. I have no family history of hearing loss
5. I feel like other people's speech isn't as clear as it used to be
6. I don't like using the telephone because it's hard to hear
7. My wife complains I have the television and radio up too loud but I can't hear them at the level she likes
8. I can hear fine in one on one situations
9. I have some difficulty with understanding conversation when there is background noise
10. I haven't had my hearing tested before
11. Sometimes I hear a ringing sound in my ears at night when the room is quiet
12. I hear the sound in both ears
13. The sound doesn't bother me
14. I would describe the sound as a high-pitched ringing
15. I've never had any balance problems
16. My face has never felt tingly, numb or weak
17. My ears don't feel full or like there's pressure in there
18. I have never had an operation on my ears, nose or throat
19. I have never been to see an ear specialist
20. I've never had any problems with my tonsils or adenoids
21. I don't remember ever getting ear infections
22. I've worked in a noisy environment for 30 years, 40 hours a week
23. I didn't wear hearing protection until the last few years
24. My general health is pretty good
25. I don't have diabetes
26. I haven't had any major operations
27. I have had no major illnesses
28. I don't have any heart or blood pressure problems
29. I have never had mumps
30. I have never had meningitis
31. I don't take any medications
32. I have never had a head injury
33. I have never had measles
34. I don't know specifically when my hearing started deteriorating
35. I first noticed the sound ten years ago or so

5. Bilateral presbycusis (flat moderate loss) with BPPV (no extra hearing loss)

- *69 year old*

1. My GP wanted me to see you because I have trouble hearing in background noise and I'm having dizzy spells
2. I feel my hearing is the same in both ears
3. I used to be a schoolteacher
4. Both my parents got hearing aids when they got older
5. I have particular difficulty with hearing conversation when there's other noise in the room
6. I can use the telephone fine as long as the volume is turned right up
7. I use my left ear on the telephone
8. I struggle to hear the radio in the car
9. I have the volume on the tv up quite loud
10. Mostly I can hear fine when I'm talking to someone in quiet

11. I have some difficulty with understanding conversation when there is background noise
12. I haven't had my hearing tested before
13. I've had tinnitus once or twice in my lifetime, but it never lasted more than a few seconds and it didn't bother me at all
14. I do get dizzy sometimes
15. Sometimes when I roll over in bed the room starts to spin
16. The feeling usually lasts around 5 - 20 seconds, but it's awful while it's happening
17. I went to see my doctor about it and she sent me to you
18. My face has never felt tingly, numb or weak
19. My ears don't feel full or like there's pressure in there
20. I have never had an operation on my ears, nose or throat
21. I have never been to see an ear specialist
22. I've never had any problems with my tonsils or adenoids
23. I don't remember ever getting ear infections
24. I have never worked in noisy environments and I don't have any really loud hobbies
25. My general health is pretty good
26. I don't have diabetes
27. I haven't had any major operations
28. I have had no major illnesses
29. I don't have any heart or blood pressure problems
30. I have never had mumps
31. I have never had meningitis
32. I don't take any medications
33. I have never had a head injury
34. I have never had measles
35. I first noticed my hearing getting worse about five years ago
36. The dizziness started two months ago

6. Bilateral sensorineural hearing loss with high frequency cochlear dead regions

- *67 year old male*
- 1. I've come to see you because my wife is concerned about my hearing
- 2. I feel my hearing is slightly better in my left ear than my right
- 3. I work as a pianist in a hotel foyer three nights a week
- 4. No one in my immediate or extended family wears hearing aids
- 5. I have some difficulty with understanding what people say to me
- 6. I play the piano, and the high notes seem to hiss
- 7. I don't use the telephone because I can't hear
- 8. I don't listen to the radio anymore because it sounds distorted
- 9. I use subtitles and captioning when watching television to help me understand what they're saying
- 10. Mostly I can hear fine when I'm talking to someone in quiet
- 11. I don't like having conversations in noisy environments because it's too hard to hear
- 12. I haven't had my hearing tested before
- 13. Sometimes I hear a ringing sound in my ears at night when the room is quiet
- 14. I would describe the sound as a high-pitched ringing
- 15. The sound stops me from sleeping
- 16. I hear the sound in both ears
- 17. I've never had any balance problems
- 18. My face has never felt tingly, numb or weak
- 19. My ears don't feel full or like there's pressure in there
- 20. I have never had an operation on my ears, nose or throat
- 21. I have never been to see an ear specialist
- 22. I've never had any problems with my tonsils or adenoids

23. I don't remember ever getting ear infections
24. I have never worked in noisy environments and I don't have any really loud hobbies
25. My general health is pretty good
26. I don't have diabetes
27. I haven't had any major operations
28. I have had no major illnesses
29. I have angina
30. I have never had mumps
31. I have never had meningitis
32. I am taking medication for my angina
33. I have never had a head injury
34. I have never had measles
35. I first noticed my hearing getting worse ten years or so ago
36. The sound started about nine years ago

7. Left Meniere's disease (rising configuration) with Right normal hearing

- *50 year old male*
- 1. My GP wanted me to see you because I'm having dizzy spells, I get tinnitus, and I'm having trouble hearing
- 2. I think my hearing changes in my left ear and is fine in my right ear
- 3. I feel my hearing is better in my right ear than my left
- 4. I have no family history of hearing loss
- 5. I work as an accountant
- 6. Sometimes I can hear well, but other times I feel like everybody seems to mumble
- 7. Mostly I can hear fine when I'm talking to someone in quiet
- 8. I have some difficulty with understanding conversation when there is background noise, particularly on days when my hearing is worse
- 9. I'm fine using the telephone
- 10. I use my right ear on the telephone
- 11. I've had to turn the tv and radio up a bit recently
- 12. I haven't had my hearing tested before
- 13. I have never worn hearing aids before
- 14. When my hearing seems to drop I often hear a strange sound in my ear
- 15. I hear the sound in my left ear but not my right
- 16. I would describe the sound as a low, roaring sound.
- 17. The sound makes me worry about what's going on in my ear
- 18. I have dizzy spells where I feel like the room is spinning around me
- 19. I remember hearing a strange sound when the room was spinning
- 20. My ear feels strange when I get dizzy spells
- 21. The dizzy feeling usually lasts for around two hours, but can be quite brief
- 22. My face has never felt tingly, numb or weak
- 23. When I have dizzy spells I can feel pressure in my left ear
- 24. I don't feel any pressure in my right ear
- 25. I have never been to see an ear specialist
- 26. I've never had an operation on my ears, nose or throat
- 27. I don't remember ever getting ear infections
- 28. I have never worked in noisy environments and I don't have any really loud hobbies
- 29. My general health is pretty good
- 30. I don't have diabetes
- 31. I haven't had any major operations
- 32. I have had no major illnesses
- 33. I don't have any heart or blood pressure problems
- 34. I have never had mumps
- 35. I have never had meningitis

- 36. I don't take any medications
- 37. I have never had a head injury
- 38. I have never had measles
- 39. My hearing got worse about 6 months ago
- 40. The dizziness started about 6 months ago
- 41. The sound started about 6 months ago

8. Right labyrinthitis (moderately severe, flat), with left mild sloping presbycusis

- *67 year old female*
- 1. My GP sent me to you because I had an attack two weeks ago where I was very dizzy, and I feel that my hearing has been worse since
- 2. I feel my hearing is better in my left ear than my right
- 3. I have no family history of hearing loss
- 4. I used to be a receptionist
- 5. I have some difficulty with hearing conversation when there's other noise in the room but this has got much worse over the last two weeks
- 6. Mostly I can hear fine when I'm talking to someone in quiet
- 7. I have some difficulty understanding conversation when there is background noise but this has got worse recently
- 8. I use my left ear on the telephone
- 9. I can hear on the telephone fine most of the time
- 10. Sometimes I can't always understand what people are saying on the tv or radio
- 11. I haven't had my hearing tested before
- 12. I have never worn hearing aids before
- 13. Two weeks ago when I had my dizzy spell I heard a loud buzzing sound, but usually I never hear any strange sounds in either of my ears
- 14. I would describe the sound as a loud buzzing
- 15. I hear the sound in my right ear but not my left
- 16. Two weeks ago I had an attack where I felt like the room was spinning
- 17. I remember hearing a strange sound when the room was spinning
- 18. The dizzy feeling lasted for 5 days
- 19. My face has never felt tingly, numb or weak
- 20. My ears don't feel full or like there's pressure there
- 21. I have never been to see an ear specialist
- 22. I've never had an operation on my ears, nose or throat
- 23. I don't remember ever getting ear infections
- 24. I have never worked in noisy environments and I don't have any really loud hobbies
- 25. My general health is pretty good
- 26. I don't have diabetes
- 27. I haven't had any major operations
- 28. I have had no major illnesses
- 29. I don't have any heart or blood pressure problems
- 30. I have never had mumps
- 31. I have never had meningitis
- 32. I don't take any medications
- 33. I have never had a head injury
- 34. I have never had measles
- 35. I first noticed my hearing getting worse ten years or so ago
- 36. The dizziness started two weeks ago
- 37. The sound started two weeks ago

9. left sudden sensorineural hearing loss (profound loss) and right noise induced hearing loss (notched loss)

- *47 year old male*

1. My GP wanted me to see you because I feel my hearing has suddenly dropped in my left ear
2. I feel my hearing is better in my right ear than my left
3. I have no family history of hearing loss
4. I work as a mechanic
5. I feel like other people's speech isn't as clear as it used to be
6. I used to be fine hearing in one on one situations, but recently it's got quite difficult
7. It's almost impossible to hear what anyone is saying to me when there's lots of other noise since my hearing has dropped
8. I use my left ear on the telephone, well, I used to, but now I can't hear in that ear
9. I can't hear on the telephone anymore since my hearing dropped but I used to do ok
10. My wife complains I have the television and radio up too loud but I can't hear them at the level she likes
11. I haven't had my hearing tested before
12. I have never worn hearing aids before
13. Since my hearing dropped I've been hearing a strange sound on that side
14. I would describe the sound as a loud hissing noise
15. I hear the sound in my left ear but not my right
16. The sound doesn't bother me but it is very loud
17. I've never had any balance problems
18. My face has never felt tingly, numb or weak
19. My ears don't feel full or like there's pressure there
20. I have never been to see an ear specialist
21. I've never had an operation on my ears, nose or throat
22. I don't remember ever getting ear infections
23. I've worked in a noisy environment for twenty years, 40 hours a week
24. I've never worn hearing protection
25. My general health is pretty good apart from my asthma
26. I don't have diabetes
27. I haven't had any major operations
28. I have had no major illnesses
29. I don't have any heart or blood pressure problems
30. I have never had mumps
31. I have never had meningitis
32. I don't take any medications other than for my asthma
33. I have never had a head injury
34. I have never had measles
35. I first noticed my hearing getting worse five years ago, but it got a LOT worse in my left ear three days ago
36. The sound started three days ago when my hearing dropped

10. Left Bell's palsy (severe/profound) on top of bilateral presbycusis (mild/moderate sloping)

- *77 year old male*
- 1. My GP wanted me to see you. because my left ear has been sore and I'm really sensitive to loud sounds, but I originally went to see the GP because my face has been weak and kind of drooping on one side
- 2. I feel my hearing is better in my right ear than my left
- 3. I have no family history of hearing loss
- 4. I used to be a lecturer in physical sciences at the local university
- 5. I feel like I can't tell which direction sounds are coming from anymore, and that other people's speech isn't as clear as it used to be
- 6. I find it difficult hearing people even in one on one conversations
- 7. I have significant difficulty hearing people in group situations



8. I use my right ear on the telephone
9. Sometimes it's hard to hear on the telephone but I do ok
10. I have the volume on the tv up quite loud
11. My children tell me the radio in my car is too loud
12. I haven't had my hearing tested before
13. I have never worn hearing aids before
14. I never hear any strange sounds in either of my ears
15. I've never had any balance problems
16. My face does feel numb and tingly
17. The right side of my face is fine, but the left side looks droopy
18. My ears don't feel full or like there's pressure there
19. I have never been to see an ear specialist
20. I've never had an operation on my ears, nose or throat
21. I don't remember ever getting ear infections
22. I have never worked in noisy environments and I don't have any really loud hobbies
23. My general health is pretty good
24. I don't have diabetes
25. I haven't had any major operations
26. I have had no major illnesses
27. I don't have any heart or blood pressure problems
28. I have never had mumps
29. I have never had meningitis
30. I don't take any medications
31. I have never had a head injury
32. I have never had measles
33. I first noticed my hearing getting worse ten years or so ago, but my left ear has been much worse for the last week or so

11. Right meningitis (sensorineural, profound mid-high frequency) and overlay of ototoxicity induced sensorineural loss bilaterally (mild high frequency)

- *18 year old*
  1. I'm here today because I noticed I couldn't hear well when I was in hospital with meningitis three weeks ago, and the doctor said I needed to get my hearing checked when I felt well enough
  2. I feel my hearing is better in my left ear than my right
  3. I have no family history of hearing loss
  4. I've just finished school
  5. I feel like other people's speech isn't as clear as it used to be
  6. When talking to someone one on one, I find I need to be able to see their face to be able to make sense of what they're saying
  7. I have significant difficulty hearing people in group situations
  8. I can't hear on the telephone anymore since my hearing dropped but I used to do ok
  9. I use my right ear on the telephone
  10. I've had to turn the tv and radio volume up a lot since my hearing dropped
  11. I haven't had my hearing tested before
  12. I have never worn hearing aids before
  13. I've never experienced tinnitus
  14. I've never had any balance problems
  15. My face has never felt tingly, numb or weak
  16. My ears don't feel full or like there's pressure there
  17. I have never been to see an ear specialist
  18. I've never had an operation on my ears, nose or throat
  19. I don't remember ever getting ear infections
  20. I have never worked in noisy environments and I don't have any really loud hobbies

21. My general health is pretty good
22. I don't have diabetes
23. I haven't had any major operations
24. I have had no major illnesses
25. I don't have any heart or blood pressure problems
26. I have never had mumps
27. I had bacterial meningitis three weeks ago and was on bed rest for two weeks
28. I was treated with high doses of penicillin, aminoglycoside antibiotics and steroids but I don't take any other medications
29. I have never had a head injury
30. I have never had measles
31. My hearing dropped three weeks ago

12. Right acoustic neuroma (normal, low frequency steeply sloping to profound high frequencies) with left normal hearing

- *54 year old female*
  1. My GP wanted me to see you because I'm having trouble hearing in my right ear
  2. I feel my hearing is better in my left ear than my right
  3. I have no family history of hearing loss
  4. I work as a bus driver
  5. I have particular difficulty with hearing on the telephone, and other people's speech isn't as clear as it used to be
  6. Mostly I can hear fine when I'm talking to someone in quiet
  7. I have some difficulty understanding conversation when there is background noise
  8. I use my left ear on the telephone
  9. I have no trouble using the telephone on my left side, but it's hard to hear using my right ear
  10. I have the volume on the tv up quite loud
  11. I haven't had my hearing tested before
  12. I have never worn hearing aids before
  13. I do get tinnitus
  14. I would describe the sound as a loud buzzing
  15. I hear the sound in my right ear but not my left
  16. The sound makes me feel stressed
  17. I've never had any balance problems
  18. My face has never felt tingly, numb or weak
  19. I feel like my ear is blocked
  20. The blocked feeling is in my right ear
  21. I have never been to see an ear specialist
  22. I've never had an operation on my ears, nose or throat
  23. I don't remember ever getting ear infections
  24. I have never worked in noisy environments and I don't have any really loud hobbies
  25. My general health is pretty good
  26. I don't have diabetes
  27. I haven't had any major operations
  28. I have had no major illnesses
  29. I don't have any heart or blood pressure problems
  30. I have never had mumps
  31. I have never had meningitis
  32. I don't take any medications
  33. I have never had a head injury
  34. I have never had measles
  35. I first noticed my hearing getting worse about five years ago
  36. The sound started about a year ago

13. Bilateral CMV with different sensorineural hearing configurations in each ear; left worst

- *16 year old male*

1. I've come to see you today because my new foster mother is concerned about my hearing – she thinks I have the television up too loud
2. I feel my hearing is better in my right ear than my left
3. I have no family history of hearing loss
4. I'm still at school. I don't like it much because all the teachers mumble and I can't hear them. My foster mum reckons that's why I'm doing so badly in all my subjects. I want to leave school.
5. I have some difficulty with understanding what people say to me
6. Mostly I can hear fine when I'm talking to someone in quiet
7. It's almost impossible to hear what anyone is saying to me when there's lots of other noise, particularly because I have bad vision so I can't lip-read
8. I don't use the telephone, my friends all text. No one uses their phones for calling anymore
9. Sometimes I can't always understand what people are saying on the tv or radio
10. I haven't had my hearing tested before
11. I have never worn hearing aids before
12. I never hear any strange sounds in either of my ears
13. I've never had any balance problems
14. My face has never felt tingly, numb or weak
15. My ears don't feel full or like there's pressure there
16. I have never been to see an ear specialist
17. I've never had an operation on my ears, nose or throat
18. I don't remember ever getting ear infections
19. I have never worked in noisy environments and I don't have any really loud hobbies
20. My general health is pretty good
21. I don't have diabetes
22. I haven't had any major operations
23. I tested positive for cytomegalovirus at birth
24. I don't have any heart or blood pressure problems
25. I have never had mumps
26. I have never had meningitis
27. I don't take any medications
28. I have never had a head injury
29. I have never had measles
30. My hearing has always been like this

14. bilateral asymmetrical noise induced hearing loss, with left moderate-severe 4-6kHz 'notch' and Right mild 4-6kHz notch, due to firearms work

- *55 year old male*

1. I've come to see you because my wife is concerned about my hearing
2. I feel my hearing is better in my left ear than my right
3. I have no family history of hearing loss
4. I work as a sheep and beef farmer
5. I have particular difficulty with hearing on the telephone and hearing at meetings and hearing at church
6. Mostly I can hear fine when I'm talking to someone in quiet, providing they're facing me when they're talking
7. I don't like having conversations in noisy environments because it's too hard to hear
8. I don't like using the telephone because it's hard to hear

9. I have to use my right ear on the telephone, which is a pain because I can't write things down while holding the phone anymore
10. Sometimes I can't always understand what people are saying on the tv or radio
11. I haven't had my hearing tested before
12. I have never worn hearing aids before
13. Sometimes I hear a ringing sound in my ears at night when the room is quiet
14. I would describe the sound as a high-pitched ringing
15. The sound stops me from sleeping sometimes
16. I hear the sound in my left ear more than my right
17. I've never had any balance problems
18. My face has never felt tingly, numb or weak
19. My ears don't feel full or like there's pressure there but my left ear can hurt a bit when there's loud or sharp noises
20. I have never been to see an ear specialist
21. I've never had an operation on my ears, nose or throat
22. I don't remember ever getting ear infections
23. I do a lot of shooting on the farm
24. I've never worn hearing protection
25. I'm a right-handed shooter
26. My general health is pretty good
27. I don't have diabetes
28. I haven't had any major operations
29. I have had no major illnesses
30. I don't have any heart or blood pressure problems
31. I have never had mumps
32. I have never had meningitis
33. I don't take any medications
34. I have never had a head injury
35. I have never had measles
36. I first noticed my hearing getting worse about five years ago
37. The sound started ten years ago

15. Left endolymphatic hydrops (moderately-severe rising to mild, then sloping to moderate) with Right otitis externa (normal hearing)

- *70 year old female*
- 1. I'm here today because my hearing in my left ear keeps changing and because my right ear has been sore
- 2. I think my hearing changes in my left ear and is fine in my right ear
- 3. I feel my hearing is better in my right ear than my left
- 4. I have no family history of hearing loss
- 5. I used to be a nurse
- 6. Sometimes I can hear well, but other times I have some difficulty with understanding what people say to me
- 7. I used to be fine hearing in one on one situations, but recently it's got quite difficult
- 8. I have some difficulty with understanding conversation when there is background noise, particularly on days when my hearing is worse
- 9. I use my left ear on the telephone
- 10. I can't hear on the telephone anymore since my hearing dropped, but I used to do ok
- 11. I have no problem hearing the television or radio
- 12. I haven't had my hearing tested before
- 13. I have never worn hearing aids before
- 14. I've never experienced tinnitus
- 15. I do get dizzy sometimes
- 16. The dizzy feeling usually lasts for a couple of hours at a time

17. I haven't been to see the doctor about it
18. My face has never felt tingly, numb or weak
19. My ears don't feel full or like there's pressure there
20. I have never been to see an ear specialist
21. I've never had an operation on my ears, nose or throat
22. I don't remember ever getting ear infections
23. I have never worked in noisy environments and I don't have any really loud hobbies
24. My general health is pretty good
25. I don't have diabetes
26. I haven't had any major operations
27. I have had no major illnesses
28. I don't have any heart or blood pressure problems
29. I have never had mumps
30. I have never had meningitis
31. I don't take any medications
32. I have never had a head injury
33. I have never had measles
34. I first noticed my hearing getting worse about a year ago
35. The dizziness started about a year ago

16. Right retracted tympanic membrane (15-25 dB rising low frequency conductive component) with symmetrical border-line normal hearing in both ears

- *27 year old*
- 1. I'm here today for a free hearing check
- 2. I work as a chef
- 3. I feel my hearing is fine, but my right ear has felt slightly blocked for the past month or so
- 4. I feel my hearing is the same in both ears
- 5. I have no family history of hearing loss
- 6. I don't really have much trouble hearing
- 7. I can hear fine in one on one situations
- 8. I have some difficulty hearing conversation in noisy restaurants
- 9. I use my left ear on the telephone
- 10. I'm fine using the telephone
- 11. I have no problem hearing the television or radio
- 12. I haven't had my hearing tested before
- 13. I have never worn hearing aids before
- 14. I never hear any strange sounds in either of my ears
- 15. I've never had any balance problems
- 16. My face has never felt tingly, numb or weak
- 17. I have never been to see an ear specialist
- 18. I've never had any problems with my tonsils or adenoids
- 19. My ears don't feel full or like there's pressure in there
- 20. I have never worked in noisy environments and I don't have any really loud hobbies
- 21. My general health is pretty good
- 22. I don't have diabetes
- 23. I haven't had any major operations
- 24. I have had no major illnesses
- 25. I don't have any heart or blood pressure problems
- 26. I have never had mumps
- 27. I have never had meningitis
- 28. I don't take any medications
- 29. I have never had a head injury
- 30. I have never had measles

31. I noticed that my hearing seemed worse about a month ago

17. Right otitis media with effusion (flat 40-50 dB loss; normal BC) and Left normal hearing

– 18 year old

1. My GP wanted me to see you because I'm having trouble hearing in my right ear
2. I've just finished school
3. I feel my hearing is better in my left ear than my right ear
4. I think my hearing is a bit down
5. My cousin has a cochlear implant, but I don't know why he needs one
6. I feel like I can't tell which direction sounds are coming from anymore
7. I can hear fine in one on one situations
8. I have some difficulty with understanding conversation when there is background noise
9. I use my left ear on the telephone
10. I have no trouble using the telephone
11. I have no problem hearing the television or radio
12. I haven't had my hearing tested before
13. I have never worn hearing aids before
14. I never hear any strange sounds in either of my ears
15. I've never had any balance problems
16. My face has never felt tingly, numb or weak
17. I have a history of ear infections
18. I don't remember ever having grommets or visiting an ear specialist
19. I get hayfever
20. My ears don't feel full or like there's pressure in there
21. I have never worked in noisy environments and I don't have any really loud hobbies
22. My general health is pretty good
23. I don't have diabetes
24. I haven't had any major operations
25. I have had no major illnesses
26. I don't have any heart or blood pressure problems
27. I have never had mumps
28. I have never had meningitis
29. I don't take any medications
30. I have never had a head injury
31. I have never had measles
32. I noticed that my hearing seemed worse about three weeks ago

18. Left tympanosclerosis (15-20 dB low-to-mid frequency conductive component) and bilateral presbycusis (moderate to profound sloping; 'off the chart' at 6 & 8 kHz)

– 85 year old

1. My GP wanted me to see you because I have trouble hearing in background noise, and he said there's a white chalky substance on my left eardrum
2. I used to be a typist
3. I feel my hearing is better in my right ear than my left ear
4. I think my hearing is quite bad
5. I have no family history of hearing loss
6. I often feel left out of conversation because I can't understand anyone
7. I find it difficult hearing people even in one on one conversations
8. I have significant difficulty hearing people in group situations
9. I use my right ear on the telephone
10. I find hearing on the telephone really difficult
11. I don't watch television or listen to the radio anymore because it's too hard to hear

12. I haven't had my hearing tested before
13. I have never worn hearing aids before
14. I do get tinnitus
15. I would describe the sound as a high-pitched ringing
16. I hear the sound in both ears
17. The sound doesn't bother me
18. I've never had any balance problems
19. My face has never felt tingly, numb or weak
20. I used to get a lot of ear infections when I was a child, but I don't anymore
21. I have never had an operation on my ears, nose or throat
22. My ears don't feel full or like there's pressure in there
23. I have never worked in noisy environments and I don't have any really loud hobbies
24. My general health is pretty good
25. I don't have diabetes
26. I haven't had any major operations
27. I have had no major illnesses
28. I don't have any heart or blood pressure problems
29. I have never had mumps
30. I have never had meningitis
31. I don't take any medications
32. I have never had a head injury
33. I have never had measles
34. I first noticed my hearing getting worse ten years or so ago
35. The sound started ages ago, I can't remember when

19. Right perforated tympanic membrane (20-30 dB conductive component) and bilateral idiopathic sensorineural hearing loss (mild, low-to-mid frequency hearing loss, sloping to moderately severe in the high frequencies)

– 47 year old

1. I'm here today because my right ear has been sore and there's been stuff coming out of it – thankfully not blood
2. I work for an advertising agency
3. I feel my hearing is better in my left ear than my right
4. I think my hearing is quite bad
5. My younger brother started using hearing aids last year
6. I don't know what caused his hearing loss
7. I have particular difficulty with hearing high-pitched noises – I often don't hear the telephone ringing
8. Mostly I can hear fine when I'm talking to someone in quiet, providing they're facing me when they're talking and as long as they don't speak too quickly
9. I have some difficulty with understanding conversation when there is background noise
10. I use my left ear on the telephone
11. I can use the telephone fine as long as the volume is turned right up
12. I have the volume on the tv up quite loud
13. I haven't had my hearing tested before
14. I have never worn hearing aids before
15. I never hear any strange sounds in either of my ears
16. I've never had any balance problems
17. My face has never felt tingly, numb or weak
18. I have never been to see an ear specialist
19. I've never had any problems with my tonsils or adenoids
20. My ears don't feel full or like there's pressure in there
21. I have never worked in noisy environments and I don't have any really loud hobbies

22. My general health is pretty good
23. I don't have diabetes
24. I haven't had any major operations
25. I have had no major illnesses
26. I don't have any heart or blood pressure problems
27. I have never had mumps
28. I have never had meningitis
29. I don't take any medications
30. I have never had a head injury
31. I have never had measles
32. I don't know specifically when my hearing started deteriorating

20. Left wax occlusion (flat 30dB conductive component) and bilateral presbycusis (mild to moderately-severe precipitous hearing loss)

- *74 year old*
- 1. I'm here today for a free hearing check
- 2. I used to be a doctor
- 3. I feel my hearing is better in my right ear than my left ear
- 4. I think my hearing is a bit down
- 5. I have no family history of hearing loss
- 6. I have trouble hearing my grandchildren, and hearing conversation when there's other noise in the room
- 7. Mostly I can hear fine when I'm talking to someone in quiet
- 8. I have some difficulty understanding conversation when there is background noise
- 9. I use my right ear on the telephone
- 10. Sometimes it's hard to hear on the telephone but I do ok
- 11. I have the volume on the tv up quite loud
- 12. I haven't had my hearing tested before
- 13. I have never worn hearing aids before
- 14. I do get tinnitus
- 15. I would describe the sound as a high-pitched ringing
- 16. I hear the sound in both ears
- 17. The sound doesn't bother me
- 18. I've never had any balance problems
- 19. My face has never felt tingly, numb or weak
- 20. I have never been to see an ear specialist
- 21. I've never had any problems with my tonsils or adenoids
- 22. My ears don't feel full or like there's pressure in there
- 23. I have never worked in noisy environments and I don't have any really loud hobbies
- 24. My general health is pretty good
- 25. I don't have diabetes
- 26. I haven't had any major operations
- 27. I have had no major illnesses
- 28. I don't have any heart or blood pressure problems
- 29. I have never had mumps
- 30. I have never had meningitis
- 31. I don't take any medications
- 32. I have never had a head injury
- 33. I have never had measles
- 34. I first noticed my hearing getting worse ten years or so ago
- 35. The sound has been there for a long time

21. Right ossicular discontinuity (flat 50-60 dB conductive component; normal BC) and Left normal hearing



– 24 year old male

1. My GP wanted me to see you because I feel my hearing has suddenly dropped in my right ear since I was in a bar fight last weekend
2. I work as an electrician
3. I feel my hearing is usually pretty good, but it's been down in my right ear since the weekend
4. I feel my hearing is better in my left ear than my right ear
5. I have no family history of hearing loss
6. My hearing used to be fine but now I feel like everybody seems to mumble
7. I can hear fine in one on one situations
8. I have some difficulty understanding conversation when there is background noise since my hearing has dropped
9. I use my left ear on the telephone
10. I'm fine using the telephone
11. I have no problem hearing the television or radio
12. I haven't had my hearing tested before
13. I have never worn hearing aids before
14. I've never experienced tinnitus
15. I've never had any balance problems
16. My face has never felt tingly, numb or weak
17. I have never been to see an ear specialist
18. I've never had any problems with my tonsils or adenoids
19. My ears don't feel full or like there's pressure in there
20. I have never worked in noisy environments and I don't have any really loud hobbies
21. My general health is pretty good
22. I don't have diabetes
23. I haven't had any major operations
24. I have had no major illnesses
25. I don't have any heart or blood pressure problems
26. I have never had mumps
27. I had meningitis when I was a baby
28. I don't think the meningitis had any lasting effects
29. I don't take any medications
30. I have never had a head injury
31. I have never had measles
32. My hearing has been worse since last weekend

22. Left otosclerosis (30-40 dB rising conductive component with Carhart's notch and mild-moderate sensorineural component) and Right idiopathic sensorineural hearing loss (mild rising to normal)

– 35 year old female

1. I'm here today for a free hearing check
2. I'm not currently employed – I'm too busy at home with my two children
3. I feel my hearing is better in my right ear than my left ear
4. I think my hearing is a bit down in my left ear – it's only started happening since I had my first child ten years ago
5. My mother's hearing got worse from her 30s onwards, but she had an operation that seemed to help – I can't remember the details because I was quite young
6. I have particular difficulty with hearing my children whisper, which they think is great fun
7. Mostly I can hear fine when I'm talking to someone in quiet
8. I have some difficulty understanding conversation when there is background noise
9. I use my right ear on the telephone
10. I can hear on the telephone fine most of the time

11. I have no problem hearing the television or radio
12. I haven't had my hearing tested before
13. I have never worn hearing aids before
14. Sometimes I hear a strange sound in my left ear
15. I would describe the sound as a loud hissing noise
16. I hear the sound in my left ear but not my right
17. The sound doesn't bother me
18. I've never had any balance problems
19. My face has never felt tingly, numb or weak
20. I have never been to see an ear specialist
21. I've never had any problems with my tonsils or adenoids
22. My ears don't feel full or like there's pressure in there
23. I have never worked in noisy environments and I don't have any really loud hobbies
24. My general health is pretty good
25. I don't have diabetes
26. I haven't had any major operations
27. I have had no major illnesses
28. I don't have any heart or blood pressure problems
29. I have never had mumps
30. I have never had meningitis
31. I don't take any medications
32. I have never had a head injury
33. I have never had measles
34. I first noticed my hearing getting worse ten years or so ago
35. The sound has been there for a long time

23. Right cholesteatoma (40-50 dB rising conductive component with mild mid-to-high frequency sensorineural component) and Left normal hearing

– 50 year old female

1. My GP wanted me to see you because I've been getting discharge from my right ear
2. I work as a manager in a clothing store
3. I feel my hearing is better in my left ear than my right ear
4. I think my hearing is fine in my left ear but bad in my right ear
5. I have no family history of hearing loss
6. I have particular difficulty with hearing conversation when there's other noise in the room
7. I can hear fine in one on one situations
8. I have some difficulty with hearing people in groups
9. I use my left ear on the telephone
10. I'm fine using the telephone
11. I have no problem hearing the television or radio
12. I haven't had my hearing tested before
13. I have never worn hearing aids before
14. I've never experienced tinnitus
15. I've felt a bit dizzy a couple of times recently
16. The dizzy feeling didn't last long
17. I would describe it as just feeling a bit woozy
18. My face has never felt tingly, numb or weak
19. I have never been to see an ear specialist
20. I've never had any problems with my tonsils or adenoids
21. My ears don't feel full or like there's pressure in there but my right ear is sore sometimes
22. I have never worked in noisy environments and I don't have any really loud hobbies
23. My general health is pretty good

24. I have diabetes
25. I haven't had any major operations
26. I have had no major illnesses
27. I have high blood pressure
28. I have never had mumps
29. I have never had meningitis
30. I don't take any medications
31. I have never had a head injury
32. I have never had measles
33. I first noticed my hearing getting worse about five years ago
34. The dizziness started about six months ago

24. Left aural atresia (60-70 dB conductive component) with bilateral idiopathic sensorineural hearing loss (mild mid frequency dip/cookie-bite configuration)

- 32 year old
- 1. I'm here today to get a custom iPod earphone made for my right ear. I don't have an ear canal on my left side – it's been that way since I was born
- 2. I work in an early childhood centre
- 3. I think my hearing is quite bad
- 4. I feel my hearing is better in my right ear than my left ear
- 5. I have no family history of hearing loss
- 6. I can't tell where sound is coming from, and I'm always having to ask people to repeat what they said
- 7. When talking to someone one on one, I find I need to be able to see their face to be able to make sense of what they're saying
- 8. I have significant difficulty hearing people in group situations
- 9. I use my right ear on the telephone
- 10. I can use the telephone fine as long as the volume is turned right up
- 11. I use subtitles and captioning when watching television to help me understand what they're saying
- 12. I haven't had my hearing tested before
- 13. I have never worn hearing aids before
- 14. I never hear any strange sounds in either of my ears
- 15. I've never had any balance problems
- 16. My face has never felt tingly, numb or weak
- 17. I was seen by an ear specialist after I was born, but they told my mum there was nothing they could do so I have never been back.
- 18. I've never had any problems with my tonsils or adenoids
- 19. My ears don't feel full or like there's pressure in there
- 20. I have never worked in noisy environments and I don't have any really loud hobbies
- 21. My general health is pretty good
- 22. I don't have diabetes
- 23. I haven't had any major operations
- 24. I have had no major illnesses
- 25. I don't have any heart or blood pressure problems
- 26. I have never had mumps
- 27. I have never had meningitis
- 28. I don't take any medications
- 29. I have never had a head injury
- 30. I have never had measles
- 31. My hearing has always been bad, but it may have got worse as I've got older – it's hard to tell because I just kind of get used to it

25. Left bullous myringitis (15-25 dB sloping conductive component) with bilateral presbycusis (moderate to severe sloping)

– 81 year old male

1. I'm here today because my left ear has been sore for the last two days
2. I used to be an insurance broker
3. I feel my hearing is better in my right ear than my left ear
4. I think my hearing is pretty bad
5. I have no family history of hearing loss
6. I feel like everybody seems to mumble
7. I find it difficult hearing people even in one on one conversation
8. I don't like having conversations in noisy environments because it's too hard to hear
9. I don't like using the telephone because it's hard to hear
10. I use my right ear on the telephone
11. Sometimes I can't always understand what people are saying on the tv or radio
12. I've had lots of hearing tests
13. I've worn hearing aids in both ears for the last 15 years, but haven't found them very helpful
14. I never hear any strange sounds in either of my ears
15. I've never had any balance problems
16. My face has never felt tingly, numb or weak
17. I have never been to see an ear specialist
18. I've never had any problems with my tonsils or adenoids
19. My ears don't feel full or like there's pressure in there
20. I have never worked in noisy environments and I don't have any really loud hobbies
21. My general health is pretty good
22. I don't have diabetes
23. I had an oral cancer surgically removed 15 months ago, and I've been healthy since
24. I have had no major illnesses
25. I don't have any heart or blood pressure problems
26. I have never had mumps
27. I have never had meningitis
28. I don't take any medications
29. I have never had a head injury
30. I have never had measles
31. I first noticed my hearing getting worse ten years or so ago

## **|Appendix IV**

Diagnostic Adult History Form used clinically at the University of Canterbury

## Diagnostic Adult History Form

Client Name: \_\_\_\_\_ DOB/Age: \_\_\_\_\_ / \_\_\_\_\_ yrs NHI#: \_\_\_\_\_

Student: \_\_\_\_\_ Audiologist: \_\_\_\_\_ Date: \_\_\_\_\_

### Reason for Referral:

### View of Hearing / Level of Concern

Onset of Loss When: \_\_\_\_\_ Sudden or Gradual  
 Fluctuation? \_\_\_\_\_  
 Better Ear? \_\_\_\_\_ Right / Left / Same

### Communication Problems

Yes / No

Hearing in Quiet vs Noise  
 Hearing in 1:1 vs Groups

Telephone:  
 Previous Hearing Aid use? Left / Right

TV/Radio:

### Family History

Yes / No

Age of onset & cause if known

### Tinnitus

Yes / No

Onset \_\_\_\_\_ Bilateral / Unilateral  
 Pitch/Description of 'Sound' \_\_\_\_\_  
 Fluctuation? \_\_\_\_\_ Level of Annoyance

### Balance/Vertigo

Yes / No

Onset \_\_\_\_\_  
 Type \_\_\_\_\_ Unsteadiness / Rotary Vertigo  
 Duration of each episode \_\_\_\_\_  
 Possible Cause \_\_\_\_\_

### Feeling of Fullness or Pressure in Ears

Yes / No

### Facial Numbness or Weakness

Yes / No

### Ear/ENT History

Yes / No

Middle Ear Problems?  
 Treatment or Surgery

### Noise Exposure

Yes / No

Occupational/Recreational  
 Duration of Exposure

Hearing Protection? Y/N

### Major illness or Operations

Meningitis / Mumps / Measles / Diabetes / Heart & B.P.

General Health  
 Medications

Head Injuries

## **|Appendix V**

Survey for second year and recent graduate audiologists

## Participant Information

*You are invited to take part in a study being conducted by researchers from the Department of Communication Disorders and the Human Interface Technology Laboratory (HIT Lab) at the University of Canterbury. This project aims to develop a virtual client simulator program to be used to supplement traditional methods of teaching clinical skills in audiology programmes.*

**The aim of this study** is to develop a realistic case history component for a virtual client simulator, which is designed as a supplementary educational tool for audiology students.

### **Who are the researchers?**

A team of researchers from the Department of Communication Disorders and the HIT Lab are conducting this study. The researchers from the Department of Communication Disorders are Elizabeth (Libby) Sanderson, Sarah Howland, Jonny Grady and Dr Catherine Moran. The HIT Lab researchers are Alexandre Heitz and Dr Andreas Duenser. This study forms part of Alexandre Heitz's PhD and Libby Sanderson and Sarah Howland's Masters degree.

### **How were participants selected?**

Second year students enrolled in and new graduates from the clinical audiology course have been invited to take part.

### **What will the research involve?**

We are asking you to complete a short survey about the questions you would typically ask when conducting a case history.

### **What are the benefits of this study?**

You will be providing us with valuable information for the development of our virtual client simulator.



### **Do I have to take part?**

No, your participation is entirely voluntary (your choice). We hope that you will participate as your results will provide us with valuable information for developing the virtual client simulator.

You may withdraw from the study at any time.

### **Will my personal details be kept confidential?**

Yes. Your anonymity will be maintained by using aliases. Access to the data collected is limited solely to the researchers named above. The data will be stored securely at the University of Canterbury for five years following completion of the project, at which time the data will be destroyed.

### **What happens to the results of the study?**

The results of this study will help us to develop the virtual client simulator. Results will be reported as part of the project in journal publications, conference presentations, and on the internet. Results will also be reported as part of Alexandre Heitz's PhD these, and Libby Sanderson and Sarah Howland's Masters theses.

If you would like a copy of the results of this study, please contact Alexandre Heitz, Libby Sanderson or Sarah Howland.

### **Who has approved this study?**

This study has been reviewed and approved by the Human Interface Technology Laboratory (HIT Lab NZ), and the University of Canterbury Department of Communication Disorders. It has also been reviewed and approved as part of the University of Canterbury Human Ethics Committee low risk process.

**Please Contact Alexandre Heitz, Libby Sanderson, Sarah Howland, Andreas Duenser or Catherin Moran if you have further questions.**

Alexandre Heitz  
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***Thank you for taking the time to complete this survey. Your answers will provide valuable information for the programming of a new Virtual Patient Simulator being developed by the Human Interface Technology Laboratory (HITLab) and the Department of Communication Disorders at the University of Canterbury.***

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Imagine you are conducting a case history interview with a new patient. Please provide one or two examples of the way you personally would ask questions to obtain the following information.

Everybody has their own style of phrasing questions for taking a case history, so please just write what comes naturally to you. If you tend to phrase the question in two or more different ways, please list all of them as examples – the more information we can get, the better.

**Reason for referral**

*e.g. "What's brought you in to the clinic today?" or "So you're having some trouble with your hearing...?"*

**Patient's view of their hearing**

**Onset of hearing loss**

**Better ear?**

**Family history of hearing loss**

**Communication difficulties**

**Hearing in quiet/one-on-one**

**Hearing in background noise**

**Hearing on the telephone**

**Hearing the television and/or radio**

**Previous hearing aid use**

**Presence of tinnitus**

**Onset of tinnitus**

**Description of tinnitus**

**Level of annoyance of tinnitus**

**Additional information about tinnitus**

**Balance problems/Vertigo**

**Onset of balance problems/vertigo**

**Description of balance problems/vertigo**

**Duration of balance problems/vertigo**

**Additional information about balance problems/vertigo**

## **|Appendix VI**

Pre- and post-test questionnaire

Name: \_\_\_\_\_

Assessment Session: \_\_\_\_\_

## To be completed prior:

The last time I conducted a case history interview under supervision was:

(please select ONE of the following)

- ☐ Never
- ☐ Within the last 3 – 4 days
- ☐ Within the last 5 -7 days
- ☐ Between 1 and 2 weeks ago
- ☐ Over two weeks ago

The last time I observed a case history interview was:

(please select ONE of the following)

- ☐ Never
- ☐ Within the last 3 – 4 days
- ☐ Within the last 5 – 7 days
- ☐ Between 1 and 2 weeks ago
- ☐ Over two weeks ago

How many clinics have you observed and/or participated in case history taking at?

- ☐ None
- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4 or more

## Please indicate on the following scales

a) how anxious you are feeling about today's session

1 --- 2 --- 3 --- 4\* --- 5\* --- 6\* --- 7\*  
not anxious at all highly anxious

\*if you circled 4 or higher, please answer the additional question at the bottom of the page

b) how confident you are in your ability to obtain all the necessary information from the patient

1 --- 2 --- 3 --- 4 --- 5 --- 6 --- 7  
not confident very confident

c) how prepared you are feeling for today's session

1 --- 2 --- 3 --- 4 --- 5 --- 6 --- 7  
extremely unprepared very prepared

Did you do any additional study or revision of notes prior to today's session?

- ☐ No
- ☐ Yes - please state approximately how many minutes \_\_\_\_\_

\*Please briefly describe what you are feeling anxious about

\_\_\_\_\_  
\_\_\_\_\_

## To be completed following:

Now that you have completed the task **please indicate on the following scales**

a) how anxious you felt *during* today's session

1 --- 2 --- 3 --- 4\* --- 5\* --- 6\* --- 7\*  
not anxious at all highly anxious

\*if you circled 4 or higher, please answer the additional question at the bottom of the page

b) how confident you are that you were able to obtain all the necessary information from the patient

1 --- 2 --- 3 --- 4 --- 5 --- 6 --- 7  
not confident very confident

c) how adequately prepared you were for today's session

1 --- 2 --- 3 --- 4 --- 5 --- 6 --- 7  
extremely unprepared very prepared

Is there anything you feel you should have done differently during today's session?

☐ No  
☐ Yes please state: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Please briefly describe one possible audiological result you might expect to find for this patient:

- if you choose to select more than one option please specify why (e.g. tick 'mild' and 'severe' for a mild sloping to severe hearing loss)

### Right Ear

Type of hearing loss

- ☐ Sensorineural  
☐ Conductive  
☐ Mixed

Severity

- ☐ Normal  
☐ Mild  
☐ Moderate  
☐ Moderately-severe  
☐ Severe  
☐ Profound

Configuration (*please state*)

\_\_\_\_\_  
\_\_\_\_\_

### Left Ear

Type of hearing loss

- ☐ Sensorineural  
☐ Conductive  
☐ Mixed

Severity

- ☐ Normal  
☐ Mild  
☐ Moderate  
☐ Moderately-severe  
☐ Severe  
☐ Profound

Configuration (*please state*)

\_\_\_\_\_  
\_\_\_\_\_

\*Please briefly describe what you felt anxious about

\_\_\_\_\_  
\_\_\_\_\_

## **|Appendix VII**

Questionnaire following training period

**If you were in the group using the simulator:**

### Question One

Did you use the simulator at all?      Y / N

***If you answered no, please skip to Question FIVE. If yes, please answer ALL questions.***

### Question Two

- a) How many different cases did you complete? (if you are unsure, please give an approximation) \_\_\_\_\_
- b) Did you attempt the same case more than once? Y / N  
If so, how many different cases did you repeat? \_\_\_\_\_
- c) Approximately how many minutes did you spend using the simulator in total? \_\_\_\_\_

### Question Three

- a) Please list five negative aspects of the simulator:

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_

- b) Please list five positive aspects of the simulator:

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_

### Question Four

Overall, how useful do you think the patient simulator program is as a tool for practicing taking case histories?

1 --- 2 --- 3 --- 4 --- 5 --- 6 --- 7  
extremely useless                      extremely useful

Do you think mandatory use of the patient simulator program should be incorporated into the clinical audiology course in the future?      Y / N

- Why/why not? \_\_\_\_\_

### Question Five

- a) What prevented or discouraged you from using the patient simulator program?

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- b) Please list at least three things that you think might have encouraged you to use the patient simulator program more often/more regularly:

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## **|Appendix VIII**

Patient characteristics for assessment one, assessment two, and assessment three

AGE: 45

**Reason for referral**

- My left ear has been sore recently and I'm having trouble hearing in that side.
- Seems to be since I had a cold two weeks ago
- Haven't been to the GP, they charge too much
- My mother recommended that I come and see you – she got her hearing aids here and she's been really happy with them

**View of hearing**

- Usually pretty good
- Onset of pain and hearing loss = two weeks ago
- Better ear = right

**Family History**

- My mum and dad both wear hearing aids
- They are in their seventies, it's just old age

**Communication**

- Fine in quiet
- Difficulty localizing sound
- Recently had trouble in background noise – restaurants and bars
- Telephone: had to start using right ear, which is a pain because I can't write when I'm on the phone
- Television: had to increase volume from 15 to 17
- Radio: turned up volume of car radio a bit as well

**Previous Hearing Aid Use**

- None

**Tinnitus**

- Sometimes when I'm in bed at night I hear a ringing sound
- Lasts about 20 seconds
- High-pitched ringing
- Doesn't bother me, I barely notice it

**Balance/Vertigo**

- None

**Facial numbness/weakness**

- None

**Feeling of fullness or pressure in ears**

- Left ear feels blocked, and is painful

**ENT history**

- Had ear infections as a child
- Can't remember ever seeing an ENT or having surgery or grommets or anything

**Noise Exposure**

- Went to a lot of concerts when I was at Uni – one every second weekend on average for three years
- Didn't wear hearing protection

**General Health**

- Good; No major illnesses; No medications; No head injury; No diabetes; No heart/blood pressure problems; No meningitis/measles
- Only operation was a nose job ten years ago
- Had mumps as a child

**Reason for referral**

1. My doctor thought I should come to see you – last time I was there I happened to mention that I've noticed I've had trouble hearing conversations
2. I suppose it's been slowly getting worse for a long time – I don't know when it started

**View of hearing**

3. I guess my hearing is pretty bad
4. I don't know (better ear)

**Family History**

5. No-one in my family wears hearing aids, although I think my Dad was quite deaf
6. Just when he got older

**Communication**

7. I do ok in quiet
8. I just tune out of the conversation when there's more than three people as I can't follow what's going on
9. Telephone: I find the telephone quite difficult
10. Television: It's fine, we've got a good sound system so I just crank it up
11. Radio: I don't listen to the radio often, never have

**Previous Hearing Aid Use/Hearing Test**

12. None

**Tinnitus**

13. I do get noises in my ears
14. Both ears
15. It's there most of the time, I can't remember when it started
16. It sounds like crickets chirping in my ear
17. It can be annoying when I'm trying to sleep, but I try not to let it bother me. It's quite loud though

**Balance/Vertigo**

18. None

**Facial Numbness/Weakness**

19. Only after going to see the dentist!

**Feeling of fullness or pressure in ears**

20. None

**ENT history**

21. I suppose I had ear infections as child, but I don't really remember
22. I can't remember ever going to see an ENT for anything

**Noise Exposure**

23. Yes, I have a noisy job – working with aircraft engines
24. I didn't wear hearing protection regularly until a few years ago – I find earmuffs uncomfortable and I like to listen to the quality of the engine
25. 40 hour weeks, forty years

**General Health**

26. Good
27. No major illnesses
28. No medications
29. I had a head injury as a teenager – I was involved in a car accident, and lost consciousness for about half an hour
30. Had no affect on my hearing
31. No diabetes
32. No heart/blood pressure problems
33. No meningitis
34. No measles
35. No major surgeries
36. No mumps

**Reason for Referral**

1. I can't hear as well out of my right ear as I used to and I want to know why
2. I first noticed this six or seven months ago

**View of Hearing**

3. My hearing used to be pretty good, but now my right ear seems to have good days and bad days
4. Better ear = left

**Family History**

5. None

**Communication**

6. Quiet = generally ok
7. Background noise = I can struggle to understand what's being said, especially if the person is on my right
8. Telephone: no problems
9. Use left ear on telephone – I'm right-handed
10. Television – I've had to turn it up over the last few months, but some days I need more volume than others
11. Radio – same for TV

**Previous Hearing Aid Use/Hearing Test**

12. I had one of those free hearing checks at an audiology clinic three years ago, and they said my hearing was normal in both ears. I can't remember which clinic it was. I've never worn hearing aids.

**Tinnitus**

13. I do notice a buzzing sound sometimes in my right ear only
14. I first noticed it around the same time as my hearing started going funny, and it's been there ever since
15. Just before I feel dizzy, the sound seems to get louder
16. It doesn't really bother me, except when it gets really loud

**Balance/Vertigo**

17. Yes, I have had a few times in the last few months where I've felt like the room has been spinning around me
18. The feeling lasted for a few hours
19. I didn't go and see a doctor, there's been a virus going around lately and a few of my friends have felt dizzy – but they were really ill for a few days. I think I just got a milder version of it

**Facial Numbness/Weakness**

20. None

**Feeling of fullness or pressure in ears**

21. Yes, sometimes in my right ear
22. Description: Sometimes it feels like there's a lot of pressure in there
23. It's not there all the time, but it seems to get worse when I hear the buzzing sound quite loud

**ENT history**

24. Never seen an ENT specialist
25. No ear infections

**Noise Exposure**

26. None

**General Health**

- |  |                        |
|--|------------------------|
| 27. Good general health, apart from that virus that made me feel dizzy |                        |
| 28. No major illnesses   |                        |
| 29. No medications   | 33. No meningitis      |
| 30. No head injury   | 34. No mumps           |
| 31. No diabetes  | 35. No measles         |
| 32. No heart/blood pressure problems                                   | 36. No major surgeries |

## **|Appendix IX**

Participant responses to the items “*please list five negative aspects of the simulator*”, “*please list five positive negative aspects of the simulator*”, “*what prevented or discouraged you from using the patient simulator program?*” and “*please list at least three things that you think might have encouraged you to use the patient simulator program more often/more regularly*”

*Please list five negative aspects of the simulator*

- The avatar doesn't understand my questions
- I can use "cheat words" i.e. "telephone" and get a response
- I can't see my previous questions i.e. they disappear after I hit enter
- You can't ask follow up questions that probe for more information
- I can't work out how to ask about ear pain
- I can't work out how to ask about fluctuations
- You can't ask questions in a way you would naturally word them. You can get away with key words only so don't have to ask full questions
- I couldn't ask specific questions
- I couldn't ask embedded questions
- The history taking isn't very realistic
- One case crashed (every time) when I asked one particular question
- Have to use specific questions to get answers
- Couldn't get answers to all questions on case history form
- You can't get into much detail (can only get general info)
- Sometimes when I put in noisy work they say they have difficulty hearing in background noise
- You can't ask if they have pain in their ears
- You can't ask if their ear fluctuate
- It freezes a lot
- No feedback given – I didn't know if I was missing things
- It was difficult to find the right words to use
- I couldn't get the information I needed
- It crashed a few times
- The problem or pathology was not stated at the end
- Responses are limited
- Only specific questions work
- Little depth
- No feedback on missing questions/answers
- Funny looking people
- Keywords not self-revealing
- Very restrictive choice of questions to ask
- Can't follow up on statements
- Too black and white answers – either repeats the answer or doesn't answer
- Crashes
- Inconsistent i.e. I'd ask about measles and she'd talk about tinnitus
- Program crashes with each login
- Voice would change/be inconsistent e.g. male patient would suddenly have female voice
- Required very specific questions – spent a lot of time asking questions that the patient wouldn't understand
- Could not ask secondary questions/follow-up questions
- Not enough possible questions
- No feedback

*Please list five positive aspects of the simulator*

- I understand that this is a work in progress and that the simulator will be valuable after some of the crashes are ironed out
- It is quite fun to interact with the patients
- It crashes way less than the masking one
- It is good for going over general areas to cover on case history
- It is helpful for practicing differential diagnosis and management
- It is easy to use
- It was quick to get responses
- The answers would lead on to further questioning
- When put together with audiograms and masking it will be fun
- Helps with memorisation
- Quite fun
- Didn't crash often
- Easy to use
- Relevant
- Would be really good to practice if it would be easier to type questions in
- It made me memorise several case history items
- It made me think about possible pathologies
- I could use it independently
- Voice made it more realistic
- Flexible learning
- Quick case history
- Reliable responses
- Good way to learn questions for case histories
- Numerous possible clients
- Safe way to practice
- Practise makes perfect
- Easy to use – intuitive
- Helps to remember important points to cover
- Quick to use
- Helps with my management process and structuring of questions in a more logical order
- Good to practise format of case history
- Virtual patient interesting to look at – patient blinks etc.
- Easy to use
- Can quickly practice multiple cases
- Flexible
- Can work at own pace
- Good for committing case history to memory
- Good to think of different pathologies

*What prevented or discouraged you from using the patient simulator program?*

- Its non-human flaws
- Time restrictions due to other assignments etc.
- The only thing that prevented me using it was a lack of time. If I had been able to load it on to my computer I could have spent more time on it
- Time and availability of the computers
- It's just a computer, no personal interaction. Really frustrating if he doesn't understand your questions
- It took a lot of time to find the right way to ask questions, and I needed feedback on what I was doing
- Time around assignments/tests; confidence with case histories anyway; difficulty at asking more specific questions
- Getting stuck on key words
- Workload. It was available on many computers but at times there were some taken. Crashes
- Time constraints – being busy with other uni work and away on the weekend
- Time

*Please list at least three things that you think might have encouraged you to use the patient simulator program more often/more regularly*

- If it was available on all the computers in the masters house
- If it would respond to all my questions
- Having the program available on my computer
- Having a set time for everyone to practise
- Being assessed on it
- If I could have been able to use it at home
- If it had been integrated into an audiological examination i.e. with audiogram and masking
- If it was on more computers
- If I had more time (always an issue!)
- If the simulator responded to more questions. It seemed that you had to use specific words to elicit answers
- If you could get answers for ALL questions that are on our case history form
- If it's easier to ask questions
- Answers given at the end of each patient
- Feedback given (or tips on how to use it)
- More time
- Greater depth and following the case through (as an option)
- Clarifying confusing case history examples
- A way to get unstuck
- A test
- More variety e.g. pediatric case histories
- Less repetitiveness
- Less workload
- Availability – having it on personal computer for example



- Being able to know what areas I'd covered or how many questions/topics I had left to cover – this would help with confidence in covering all required information
- If it wasn't so hard to find the right way to ask the questions
- More time
- If I had been in the first group I would have had more time to allocate to practice